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Nematode Parasites of Termites

By R. H. Van Zwaluwenburg

Mr. Pemberton's importations of nematode worms of the genus *Rhabiditis* found within various termite species in Celebes and North Borneo, have renewed interest in the possibility of finding parasites effective against the notorious *Coptotermes formosanus* Shiraki (= *C. intrudens* Oshima) now so destructive in Honolulu.

Records in literature, of nematode worms in termites, are few. Mr. Muir has already (*The Hawaiian Planters' Record,* April, 1926) called attention to a paper by Lespés (*Ann. Mag. Nat. Hist.* 2nd Ser. XIX, p. 388) in which he discusses *Isacis migrans* parasitic upon termites and causing their death.

In 1919, Theiler, working in South Africa, described *Filaria gallinarum,* a nematode attacking barnyard fowls, which requires an intermediate host, the worker of *Hodotermes pretoriensis* Fuller for its complete life-cycle. This is a ground-inhabiting termite which forages above ground during the day; the larval stage of the *Filaria* lives in the abdomen of the worker caste only. Infested termites are eaten by chickens, the nematode develops to full maturity within its new host, and produces eggs which are later passed out by the fowl. It is believed that the eggs hatch after being swallowed by the termite worker and the nematodes find their way into the coelomic cavity of the insect.

These observations are of especial interest to us, because they suggest a possible reason why efforts have so far failed to breed this Celebes species of *Rhabditis* (which Mr. Pemberton found only as larvae within the abdomen of its termite host) : due to the absence in these Islands of the alternate host necessary for the completion of the nematode's life-cycle. We do not know what the essential alternate host is in this case, or even that an alternate host is necessary. These observations show that a greater knowledge of the life-cycle of each nematode species is of the utmost importance before we can hope to establish them as parasites on our termites.

The South African termite-chicken nematode is not stated to be an important death factor of the termites. There are, however, other nematodes which do cause the death of termites. *Reticulitermes lucifugus* (Rossi) of the United States is parasitized by *Diplogaster aerivora* Cobb (or a closely related species) which occurs in the head only, and in heavy infestations causes the termite host to become sluggish and often to die. (Snyder, Bull. 108, U. S. Nat. Mus., 1920, p. 117.) The same termite is similarly affected by infestations of *Rhabditis janeti* (Lac.-Duth.) which also confines itself to the head of the host. In the rubbish of nests of the same species, two other nematodes were found: *Rhabditis dolichura* (Schneider) and *Diplogaster attenuatus* Cobb (?); "they are probably very common feeders on decaying organic matter."

Ruttledge (Parasitology, Vol. 17, 1925, p. 187) records a nematode of the family Mermithidae, in the body of the South American *Cornitermes orthocephalus* Silv. Its effect upon the host is not stated, though worms of this family usually cause death of their insect hosts.

Linstow (*Jena. Zeitsch. Naturw.* 1901, n. s. XXVIII, p. 418) describes another Mermithid, *Spinifer fulleborni,* from a termite nest near Lake Nyassa, Africa. This is also presumably a true parasite.

E. Hegh in 1922 (Les Termites; partie generale; Brussels, p. 598) records a *Mermis* found by Silvestri in the abdominal cavity of a soldier termite, *Thoracotermes brevinotus* Silv., in French West Africa.

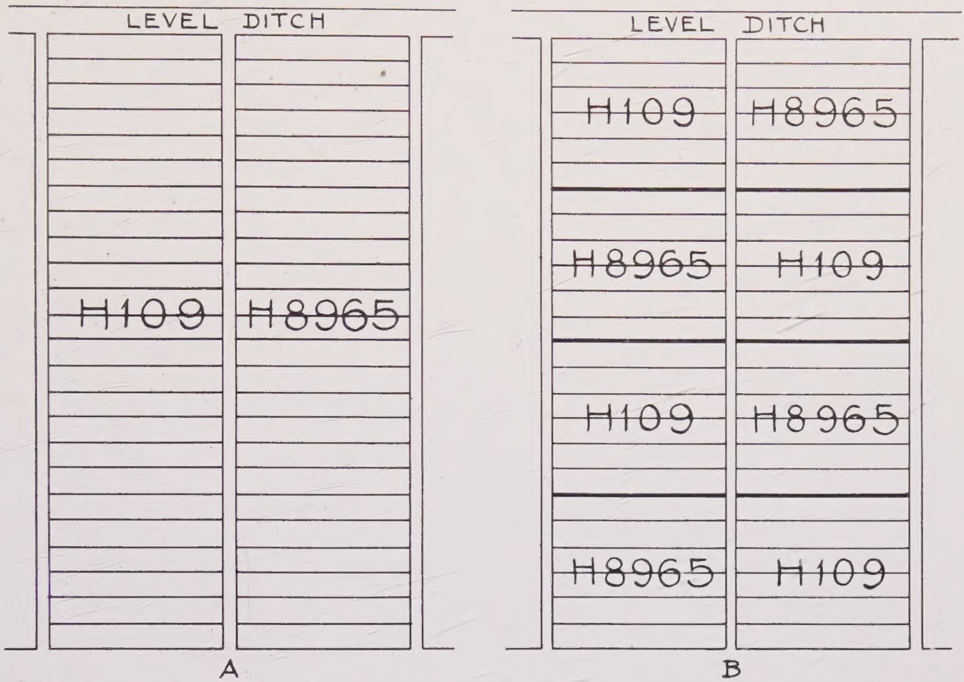
Variety Testing

By J. A. Verret and A. J. Mangelsdorf

That check plots or replications are essential to reliable results in yield trials is now generally recognized, so far as fertilizer experiments are concerned. It appears that this is not the case, however, in variety testing. We still find attempts being made to arrive at the comparative yielding ability of two varieties from the yields of single watercourse or level ditch plots. That such a procedure may be misleading in the extreme, even though the two plots are side by side, is obvious when one considers the variations in yield between adjoining watercourses and level ditches planted to one and the same variety, under the same treatment.

It is not strange that the necessity for check plots and replications has come to be realized in fertilizer trials sooner than in variety tests. In the former, inconsistencies in yield are easily seen. The following example will serve to illustrate:

Plot No.	Pounds Nitrogen Applied	Yield Tons Sugar per Acre
1	150	8.6
2	175	8.5
3	200	9.4



Two ways of utilizing the same area in a variety test. The first is easier to harvest, but the time and labor expended in obtaining yield data on such a layout are largely wasted, since very little reliance can be placed on the figures obtained. The second layout requires more care and supervision in harvesting, but the figures obtained should give a fairly reliable indication of the relative yields of the two varieties under the conditions of the experiment.

We are struck at once with the fact that the data are inconsistent—the necessity of replications to offset soil variation, if reliable figures are to be obtained, is obvious.

Turning now to variety tests, we obtain for example, from three plots the following data:

Plot No.	Variety	Yield Tons Sugar per Acre
1	U. D. 1	3.9
2	U. D. 110	3.7
3	K 202	1.9

We are likely to accept these data as actually indicating the relative yielding capacities of the three varieties, in spite of our knowledge that single plot trials are no more likely to give us reliable results in variety tests than in fertilizer tests. The reason for our less critical attitude toward the results of variety tests no doubt has its roots in the fact that we have no basis on which to detect the inconsistencies.

Very little reliance can be placed on figures obtained from experiments like the one just described. It is true that if single plot trials of this kind are repeated, let us say, for three successive years, each year in a different location, the results taken together are fully as reliable as those from a single trial with three replications. Unfortunately, however, this is seldom done.

The remedy is, of course, known to all of us. There must be a sufficient number of check plots, or replications, or both, to insure reliable results. One check plot of a standard variety to two of the varieties being tested, with the entire series repeated at least once, is about the minimum upon which any reliance can be placed. The more variable the soil or moisture conditions, the more replications will be required to obtain the same degree of reliability. If check plots are not used the series should be repeated at least twice (three replications). The greater the number of replications the more dependable the results, other things being equal.

Molasses as a Fertilizer to Cane Soils in Mauritius

In Bulletin No. 28, General Series of the Department of Agriculture, Mauritius, 1923, "The Application of Molasses as a Fertilizer to Cane Soils in Mauritius," H. A. Tempany and France Giraud discuss this question. According to these authors, the practice of applying molasses to cane soils in Mauritius dates back to 1860 but it did not become general till about 1900.

In discussing previous work on this subject, they mention Peck's work in Hawaii and remark: "It is curious that from Hawaii no results, so far as the writers are aware, have been recorded for tests in the fields."

The usual practice in Mauritius is to apply 4 tons or 836 gallons per acre, but the quantity varies and as much as 15 tons per acre have been applied.

The following are their general conclusions:

1. Planting practice in Mauritius favors the application of molasses to cane fields and evidence goes to show that such applications occasion considerable increases in yield. Rates of application range from 4 to 15 tons per acre.

2. The correctness of this view was originally indicated by experiment conducted by Boname and confirmed by experiments in Java. These observations have since been further confirmed by two separate sets of experiments, the results of which indicate that in virgin canes the increase in yield resulting from applications of molasses under the conditions of experiment may be expected to amount to 9.65 tons of cane per acre.

3. Considerations drawn from other experiments show that these increases are too large to be attributed entirely to the plant food conveyed by the molasses to the soil; consequently some other contributing cause must be sought, this is probably biological in nature.

4. Ebbels and Fauque have suggested that stimulation of nitrogen fixation by Azotobacter in consequence of the addition of sugar is the explanation. This, however, is denied by de Sornay. In point of fact the action of Azotobacter is very variable and is liable to be affected by other activities of the nitrogen cycle of which it forms part.

5. The presence of Azotobacter in Mauritius soils has been demonstrated and its activity estimated.

6. Continuous laboratory investigations extending over more than one year have, however, shown that on ordinarily rich soils addition of molasses does not increase the rate of nitrogen fixation, although it may evolve more active strains of Azotobacter.

7. On the other hand Azotobacter is apparently an important factor in soil maintenance and enrichment; but in presence of the abundant supplies of organic matter and nitrogen usually present in Mauritius soils it appears that addition of molasses usually fails to stimulate nitrogen fixation. On poor soils it is possible that the effect would be different.

8. The most marked action of molasses applications is in relation to nitrification; after molasses is applied this process is entirely suspended and in addition nitrates primarily existing in the soil disappear, being apparently reverted to the insoluble form.

9. It appears that one of the principal effects of molasses application is the partial sterilization of the soil in consequence of which the ordinary soil organisms are for the time being greatly reduced in numbers while other organisms, notably moulds and torulae, are stimulated. The latter may be of importance in relation to reversion of nitrogen to the insoluble form.

10. Subsequently nitrification is resumed at an enhanced rate and probably leads to accumulation of nitrates just at the time they can best be utilized by the growing plant.

11. The tendency of ammonia and nitrates to revert to the insoluble form is very marked in Mauritius soils and it seems not unlikely that molasses applications may have the effect of neutralizing to some extent applications of nitrogenous fertilizer by causing their nitrogen to revert in this way.

12. In addition the following other effects may be present and operative in a greater or less degree:

(a) The direct effect of the plant food added in the molasses.

(b) Liberation of plant food from unavailable reserves owing to fermentation actions.

(c) Improvement in the physical conditions of the soil owing to flocculation of the clay particles by molasses.

13. Regarding the effect of molasses applications observed on subsequent crops of ratoon canes, it is believed that it is to be attributed more to the increased vigor imparted to the virgin canes than to persistence of favorable conditions in the soil.

14. Owing to the effect which molasses can exercise on the biological process of the soil it is important that they should be applied in such time and in such manner as not to cause injury to growing crops.

If this precaution is neglected considerable harm may result inasmuch as molasses, causing as it does a complete temporary arrest of nitrification and reversion of nitric nitrogen to the organic form, can, if applied to soils in which canes are in full vegetation, do considerable damage.

In the foregoing pages the position in relation to this important and intricate problem has been reviewed at length and the results of further experimental work recorded. It is believed that although certain points admittedly remain obscure a good deal has been done to throw light on the question.

F. M.

Notes on the Mexican Tachinid, *Archytas cirphis* Curran, Introduced Into Hawaii as an Armyworm Parasite

By O. H. Swezey

This Tachinid fly was introduced from Mexico in 1924. H. T. Osborn found it parasitizing *Cirphis latiuscula* (Herr.-Sch.) in sugar cane fields at Los Mochis, Sinaloa, Mexico. A batch of parasitized chrysalids was received from Mr. Osborn February 12, 1924, from which fifteen flies issued February 12 to 26. Nine of the flies were liberated February 25 at the Federal Agricultural Experiment Station where there were armyworms in an area of nut grass. No attempt was made at rearing them in the insectary.

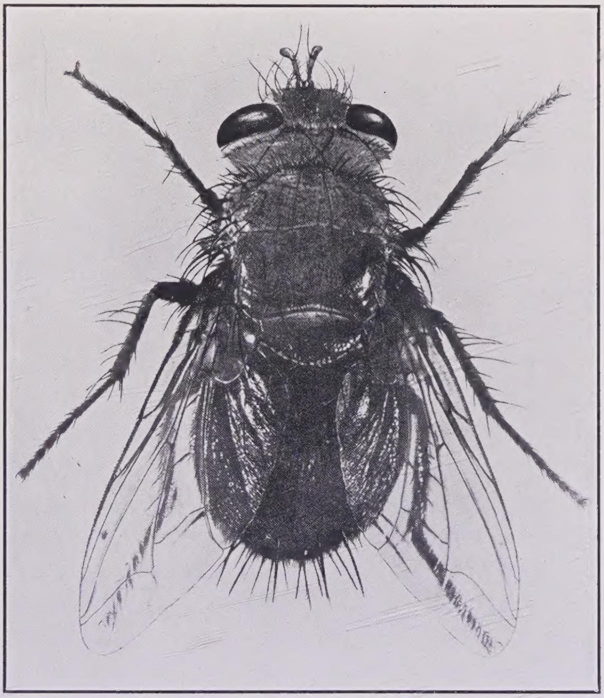
The first intimation that this Tachnid had become established was on February 20, 1925, when Dr. Williams observed one or two in the Experiment Station grounds not far from the original liberation. Thereafter a lookout was kept for them whenever opportunities occurred, and recoveries were made as follows, showing wide distribution on Oahu and first appearance on the other islands:

Dates and Places of Recovery

1925. February 20. Federal Experiment Station, Honolulu. (Williams.)
February 23. Manoa Cliffs Trail on Mt. Tantalus, about 1500 ft. (Swezey.)
March 10. Experiment Station, H. S. P. A., inside on window. (Williams.)
March 28. Thurston Ave., Honolulu, numerous on milkweed. (Rosa.)
April 21. Federal Experiment Station, very numerous on corn. (Rosa.)
May 15. Ewa Plantation, Field 9, 3 flies on weeds. (Swezey.)
June 11. 2048 Lanihuli Drive, Manoa, 1 fly in garden. (Swezey.)
June 21. Mt. Tantalus, Twin Peaks, 2 flies on Hilo grass. (Swezey.)
June 29. Tree nursery in Makiki Valley, 2 flies on Alternanthera. (Hadden.)
July 4. Mt. Tantalus, near Mrs. Swanzy's, 2 flies on grass. (Swezey.)
July 12. Waimanalo, Olomana Needle, near summit, 1 fly. (Swezey.)
July 19. Opaeula about 1500 ft., in forest, several flies. (Swezey.)
August 16. Mt. Kaala, mauka of target range. (Williams.)
October 3. Oahu Sugar Co., Field 14B. (Swezey.)
October 9. Waialua Agricultural Co., Field Mill 9. (Williams.)
October 12. Waialua Agricultural Co., Field Gay 3. (Swezey.)
October 11. Sacred Valley, windward Oahu. (Hadden.)
October 26. Waialae Ranch. (Swezey.)
1926. March 4. Maui, Hawaiian Commercial & Sugar Co., Field E, numerous. (Muir.)

March 5. Maui, Wailuku Sugar Co., near Field 97, numerous. (Van Zwaluwenburg.)
March 5. Maui, near Sanitarium in Kula. (Muir.)
March 16. Wailupe, Hind-Clarke Dairy. (Hadden, Swezey.)
March 30. Kualapuu, Molokai, at G. P. Cooke's residence. (Wilder.)
May 9. Hilo, Hawaii, Hilo Hotel garden and at cemetery. (Swezey.)
June. Molokai, in pineapple fields. (Illingworth.)

1927. February 9. Kauai, Lihue Hotel grounds. (Williams.)
February 9. Kauai, Lihue Plantation, Field L4. (Williams.)
February 10. Kauai, Kilauea Plantation, Field 15. (Williams.)
February 13. Kauai, Summit Camp on Electric Power Line trail. (Williams.)
April 3. Palehua, south end of Waianae Mts. (Swezey.)
April 10. Kolekole Pass, Waianae Mts. (Swezey.)



Archytas cirphis, the Mexican Tachinid armyworm parasite. X5.

Distribution to Other Islands

In April, 1925, when the flies appeared numerous on corn (attracted to honey dew from aphis and leafhoppers) at the Federal Experiment Station, an attempt was made to distribute them to the other islands. A colony of forty flies was captured and sent in a large carton by mail to Olaa Sugar Company, April 21. None of them survived the trip. No further attempts were made till July, when Mr.

Van Zwaluwenburg, who was making an inspection trip to Kauai, took along 21 that had been captured. Ten of them survived the trip. These were liberated in the garden at the Lihue Hotel. Apparently these were sufficient to give them a start, for they were found in several widely separated places by Dr. Williams in February, 1926.

On September 8, 1925, and March 16, 1926, colonies were collected and sent by L. W. Bryan when he was returning to Hilo. Of these, six and eleven, respectively, survived and were liberated, and served to effect the establishment of the parasite on Hawaii. A few flies were recovered by the writer, May 9, 1926, on flowers in the Hilo Hotel garden and at the Hilo Cemetery. As yet the fly has not been recovered at any other locality on the island of Hawaii, but no doubt it is quite widely spread by this time.

No effort was made to distribute this fly to Molokai or Maui, but it reached these Islands somehow, as shown by the dates of recovery above in March, 1926.

Life History Notes

No attempts had been made at rearing this fly, and its larvipositing habit was not known till on September 3, 1926, when a fly was observed to deposit a tiny maggot on a leaf of Bermuda grass on a ditch bank in Field Mill 9 of Waialua Agricultural Company. The leaf with this maggot was collected, and at 8 a. m. the next day it was transferred to a half-grown caterpillar of *Spodoptera mauritia,* the nut grass armyworm. The transference was made by placing the piece of grass leaf in contact with the caterpillar. As soon as the maggot came in contact with the surface of the caterpillar it became active and soon shifted to the surface of the caterpillar. It almost immediately located transversely in the segmental wrinkle anterior to the first abdominal proleg, on the left side. It remained in this position until about four hours later when it was found to have penetrated half way into the caterpillar. When next observed two hours later it had entirely disappeared and there was a black dot at place of entrance. Five days later the caterpillar pupated, and later on it showed a black spot on base of right wing sheath, where it was presumed that the parasite maggot was located. However, at the end of twelve days a crippled moth issued, showing that the parasite larva failed to develop.

In September, 1926, several flies were captured in the field, and confined in a cage with growing grass, but without any caterpillars. After a few days, on examination, quite a number of the tiny maggots were found on the grass leaves. In most cases they were near the margin of the leaf and parallel to it. A number of attempts were made at rearing these maggots through to adult flies, but only a few were successful. Out of fifty-five of the maggots that were transferred to caterpillars of *Spodoptera mauritia,* only four developed to adult flies. This was sufficient, however, to indicate the length of life-cycle.

In one instance, nineteen of the maggots were transferred to caterpillars, one to each, on September 28. On October 5 to 6 the caterpillars were pupating. On October 17, some moths were found to have issued and died. Three chrysalids

were found to contain puparia of *Archytas,* one in each. From these the adult flies issued October 26-28, making twenty-eight to thirty days from the time of transference of maggot to caterpillar. In another instance it was thirty-one days to the emergence of the fly from the puparium.

It is known that the fly produces a large number of maggots, but it must be that a very high percentage of them perish because of the small chance of a host caterpillar coming within reach. Yet, on the island of Oahu, *Archytas cirphis* has been able to keep up its existence, even though host caterpillars are apparently scarce, as there has not been any outbreak of these caterpillars since the first liberation of the flies occurred. It has not been determined how long the flies can live. Apparently there could be a new brood each month throughout the year, though the life cycle would no doubt be lengthened in the cooler part of the year, the same as is known with others of our insects.

Thus another armyworm enemy is permanently established and widely spread in the Hawaiian Islands and a valuable addition to the following list of introduced parasites on armyworms in Hawaii:

Tachinidae, *Frontina archippivora* Will. From U. S. A.
Chaetogaedia monticola (Bigot). From U. S. A.
Archytas cirphis Curran. From Mexico.
Ichneumonoidea, *Amblyteles purpuripennis* (Cress). From U. S. A.
Amblyteles koebelei (Swezey). From U. S. A.
Hyposoter exiguae (Vier.). From California.
Proctotrypid Egg-Parasite, *Telenomus nawai* Ashm. From Japan.
Chalcid-Fly, *Euplectrus platyhypenae* Howard. From Mexico.

Investigations of Natural Enemies of Borers Allied to the Sugar Cane Borer *Rhabdocnemis obscura* Boisd. In the East India Archipelago

February, 1925-March, 1927

By C. E. Pemberton

On February 13, 1925, the writer left Honolulu en route to the Philippines and the Malay Archipelago to investigate natural enemies of the sugar cane borer *R. obscura,* or borers allied to it, with the special object of finding, if possible, natural enemies other than the Tachinid parasite *Ceromasia sphenophori* Vill., found in Amboina, Ceram and New Guinea by Mr. Muir and successfully transported to Hawaii in 1910. As planned, the region requiring special attention was the island of Celebes.

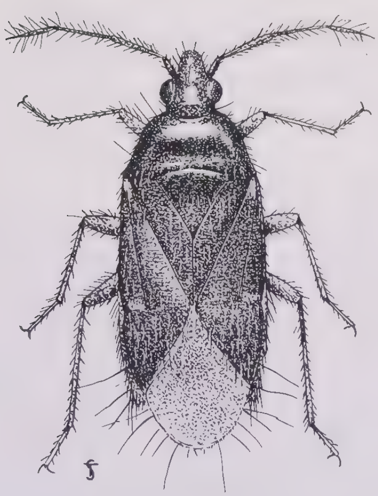
Before proceeding to Celebes, it seemed desirable to stop in the Philippines long enough to obtain shipments of a Larrid wasp, *Larra luzonensis* Rohwer, which, in 1917, was there found by Dr. F. X. Williams to be parasitic on the mole cricket *Gryllotalpa africana* Beauv. Williams' experience with this wasp indicated that a successful establishment of it in Hawaii would probably require the shipment of a good number at one time. With this object in view, living quarters were secured on the grounds of the College of Agriculture at Los Baños, P. I., and a search was commenced for the wasp in the open fields at the base of Mt. Makiling. After seven weeks of constant search in these fields without success, one female wasp was finally seen and caught in a cornfield on April 29. It was feeding on the sweet honey dew excretions of plant lice. This suggested a method for obtaining more. A concentrated solution of sugar and water was daily thereafter made up and sprayed on some of this corn. In a few days this resulted in the attraction of quantities of ants, bees, flies and wasps, among which would occasionally appear a female of the mole cricket parasite. A total of 19 females were soon caught and breeding operations were immediately started. As soon as a few females were obtained, search was made for a locality where mole crickets could be collected in quantity. At first this also became a problem, but after a few weeks of strenuous digging in the mud along the banks of the Molawin River, in flooded rice fields, etc., a place was finally found on the swampy borders of Lake Laguna, near Los Baños, where mole crickets could be obtained in fair numbers.

By confining the wasps singly in glass jars containing an inch or two of moist sand and a few fresh leaves, daily sprinkled with droplets of honey and water, they could be kept alive and active for several weeks. Individual mole crickets were placed in these jars once or twice daily. As soon as parasitized by the wasps, they were removed and placed in two-ounce ointment tins filled with moist soil and shipped to Honolulu. Three successive lots were sent. By such a method the parasite reached Hawaii in the cocoon stage. Advance information obtained by Dr. Williams in 1921, was essential and useful in the conduction of this work to a rapid and successful termination. His original account of its habits appears in brief summary in *The Hawaiian Planters' Record,* Vol. XXXI, No. 1, pp. 4-6, January, 1927.

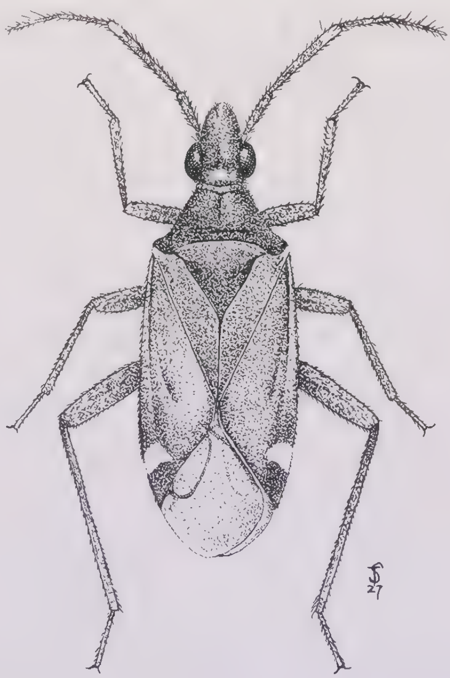
In all, 577 parasitized mole crickets were obtained and shipped to Honolulu by June 15. Of these 324 arrived in good condition. The wasps of both sexes emerged and were liberated on Oahu in upper Manoa Valley and at Ewa, Waialua and Kahuku plantations, where mole crickets were known to be present. These liberations insured the establishment of the wasp on Oahu, for at the present writing, March 22, 1927, the entomologists of the Station have found it at all localities of liberation excepting Kahuku, and Dr. Williams has even recovered it from Mt. Tantalus at an elevation of 1800 feet. It has also been seen at Waikiki well removed from the nearest point of original liberation. This wasp should, in time, contribute considerably towards a control of the mole cricket, especially since it can operate in Hawaii free from suppression by its own natural enemies, such as attack it in the Philippines.

While at Los Baños, one shipment of nut grass *Cyperus rotundus* Linn., comprising 500 bulbs, containing larvae or pupae of the nut grass moth *Bactra truculenta* Meyr., or the nut grass weevil, found by Dr. Williams in 1921 in the Philippines, was made on March 25. Again in January, 1926, two shipments, totaling 1250 affected bulbs were sent. Insect material from these lots reached Honolulu alive and was liberated. The moth is now well established in nut grass about the Experiment Station grounds in Honolulu. The weevil is also established. Mr. Rosa recovered one individual from nut grass on the Station grounds April 29, 1927.

A species of Rhabdocnemis (*Rhabdocnemis lineatocollis* Heller) being endemic in certain palms in the Philippines and being allied to our cane borer *R. obscura,* decision was made to remain in the Philippines and study the natural enemies of this beetle before proceeding south to Java, Celebes, etc. Any parasites or predators it might have would be well worth a trial on *obscura.* This work was com-



Mirid bug, predatory on eggs of *Rhabdocnemis* in Philippines, Java, Celebes and Borneo.



Anthocorid bug, predatory on eggs of *Rhabdocnemis* in Philippines, Java, Celebes, and Borneo.

menced about June 16, 1925, and continued until March, 1926. The Philippine borer normally inhabits the thick, woody, leaf-stems or trunks of palms wherever splits, cuts or other wounds occur. It is most readily found in the bases of mature, drooping, splitting leaf-stems of the Philippine sugar palm, *Arenga pinnata* (Wurmb.) Merr. This tree is abundant and an important forest element on Mt. Makiling to an elevation of 1500 to 1800 feet.

Continued studies of this beetle ultimately revealed two parasites; one a Tachinid fly quite different from our *Ceromasia,* but of similar habit; and the other an *Ichneumon* wasp parasitic on the borer pupa. Both were rare and not sufficiently different in habit from *Ceromasia* to prove of likely added importance in Hawaii if introduced. Enough fly puparia were secured, however, to make a small shipment. Some of these reached Honolulu alive and were liberated by Dr. Williams at Honokaa. It is too soon to know the result. It is doubtful if it became established.

This Philippine borer appeared to be suppressed primarily by predatory enemies. These were found to be three species of Hydrophilid beetles, *Dactylosternum hydrophiloides* M'Leay, *D. dytiscoides* F. and *D.* near *cycloides* Knisch; one Histerid beetle, *Platysoma abruptum* Er.; one Elaterid beetle, *Agrypnus* sp.; a Leptid fly, *Chrysopilus ferruginosus* Wied.; an Anthocorid bug; a Mirid bug and a centipede. The larval stages of the Hydrophilids, Histerid, Leptid and Elaterid all prey upon the borer larva. The centipede has a similar habit. The small, active Anthocorid and Mirid bugs (see figures), both young and adults, suck the juices of the borer eggs. They probably feed on the eggs of other small insects for they were several times seen feeding on eggs of Acari. These egg-sucking bugs can be found in cracks, crevices, borer channels, trash, etc., about the palms where the beetles occur. They were not seen elsewhere. Of the predators, the Leptid fly seemed to be the most useful. Its larvae feed on all stages of borer grubs and can also penetrate the woven, fibre cocoon and destroy the pupa. This was several times observed. The fly is not specifically predatory on *Rhabdocnemis,* since it sometimes can be found abundantly present within banana stumps containing banana borers, *Cosmopolites sordida* Chev. However, during the entire period of borer investigation in the Philippines, Java and Celebes, the larvae of this fly were always found either amongst palm borers (*Rhabdocnemis* sp.) or the banana borer. It was never found in any other situation. It was not found in Borneo.

Between October 5, 1925, and February 9, 1926, ten separate insect shipments were made to Honolulu from the Philippines, composed of either Mirids, Anthocorids, Hydrophilids, Histerids or Leptids. All of these species, reached Honolulu alive, in fair quantities, and were liberated in the cane fields at Honokaa, excepting the Leptid flies which were all liberated in upper Manoa Valley and on Mt. Tantalus. The predatory centipede and elaterid, above mentioned, were not shipped, the latter being too scarce to collect in sufficient quantity for a satisfactory consignment, and it was considered inadvisable to introduce the centipede.

The great success of the introduced Mirid *Cyrtorhinus mundulus,* as an egg-sucking predator on the sugar cane leafhopper in Hawaii gives some hope for success with the Philippine Anthocorid and Mirid, which feed on borer eggs there.

It is yet too soon to know the results of these introductions. To date there is no proof that any of these borer enemies have become established. It is of interest that the Histerid *Platysoma abruptum* Er., included in the shipments from the Philippines, was also studied by Mr. Muir while in Amboina in 1907 and sent in quantity to Honolulu with Hydrophilids. These were liberated but never became

established and it is quite possible that the Philippine introductions may suffer the same fate.

Jepson originally recorded the feeding habits of the Leptid fly.

Finding nothing further of importance on *Rhabdocnemis*, after having examined quantities of eggs and thousands of larvae, pupae and adults on the mountain during the year, passage was secured from Manila to Java, via Singapore on March 12, 1926. Malaria was contracted at Los Baños, in the Philippines, shortly before leaving. This persisted for several months, after reaching the Dutch East Indies, in spite of treatment, and retarded general activities for short intervals. Using Buitenzorg, Java, for headquarters where ample laboratory facilities were kindly offered by the Dutch Government Department, especially the Instituut voor Plantenziekten, studies in West Java of *Rhabdocnemis leprosus* Fahrs., a Calandrid beetle allied to our cane borer, were begun. This work extended from April 2 to July 6, 1926. Regions were visited at various points within a radius of 150 miles of Buitenzorg, especially the mountainous interior to the south and east of this city, to an elevation of about 4,500 feet. The Java beetle was found boring in the woody leaf stalks and injured trunks of the East Indian sugar palm *Arenga saccharifera* Wurmb. None was found in sago palms or in sugar cane. The beetle was by no means common. Some weeks of searching were expended before any were found at all.

No parasites were bred during the entire period though a good quantity of eggs, larvae, pupae and adults were finally collected and examined in the places visited. The control factors appear to be solely fungous diseases and predatory enemies. The latter were the same or forms closely allied to those species found in the Philippines and sent to Hawaii. The egg-sucking Mirid and Anthocorid bugs, the Hydrophilids, Histerid and Leptid appeared to be the same and usually one or more of these were present where borers were found, if careful search were made. The scarcity of this borer in Java appeared to be owing primarily to the presence of a fungous disease of a type quite distinct from any found in the Philippines or already present in Hawaii. As noted below, an effective fungous disease somewhat similar to this was also found on *Rhabdocnemis* in North Celebes some months later. On a few occasions, while in Java, as high as 50 per cent of the borer larvae, pupae or adults found in *Arenga* tissue were dead with this fungus. This was shipped to Honolulu and found by the Station entomologists to develop successfully on *R. obscura*. Mr. Barnum, of the pathological department, has further demonstrated a high mortality amongst *obscura* larvae and adults exposed to this fungus and has succeeded in developing it also on other insects, especially roaches, which die usually within six days after inoculation. This and the Celebes fungus (see figures) have been propagated at the Station, and living, freshly infected beetles distributed to various plantations to facilitate its distribution.

Several weeks were spent at Buitenzorg, Java, in a study of a nematode often found massed on the under surface of the elytra and in the sutures of the dorsum

A

B

C

D

A—Celebes fungus. Early stage of development on *Rhabdocnemis* larva.
B—Celebes fungus. Advanced stage of development on *Rhabdocnemis* larva.
C and D—Celebes fungus. Advanced stage of development on *Rhabdocnemis* adult, dorsal and ventral views.

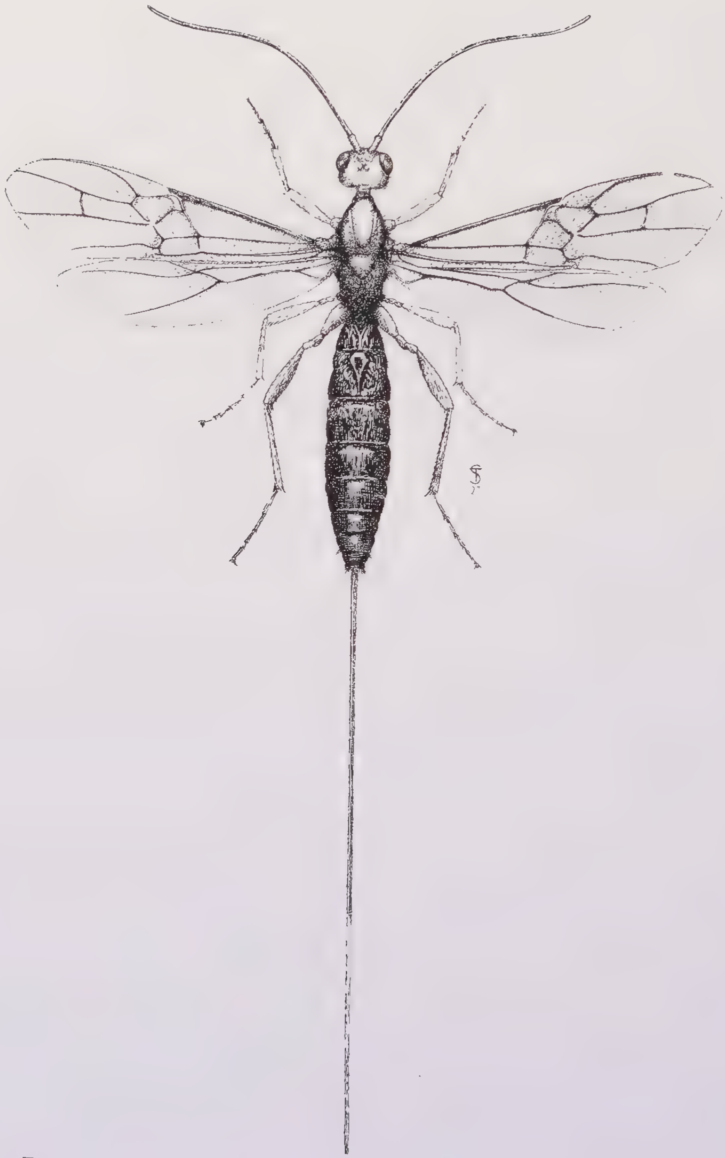
of the abdomen of living *Rhabdocnemis, Rhyncophorus* and *Sphenophorus* beetles. This was also found occasionally in dead larvae of *Rhabdocnemis* and *Sphenophorus.* The nematode developed most readily on the beetles after they had died. All experiments ultimately indicated that the nematode was more a scavenger in nature than a parasite.

A small *Sphenophorus,* abundantly present in fermenting sago palm stumps, was collected in quantity but no parasites were reared. The predatory and fungous enemies above noted on *Rhabdocnemis* appeared to be the most important control factors. This includes the egg-sucking bugs.

Passage was secured from Batavia, Java, to Menado, North Celebes, on July 7, 1926. After a voyage of 17 days with many stops, headquarters were established in a small Dutch hotel at Menado. In a few days' time a *Rhabdocnemis* very similar to *R. obscura,* was found in sugar palms near Menado. A fine forest, well stocked with sugar palms, as shown in the accompanying illustrations, was located about 12 miles from Menado, where the beetle was found in fair abundance. After securing the necessary authority from the Dutch Resident of the district and proper introductions to the native chief of the village of Tateli, adjacent to the forest, an intensive study was begun in this locality. A native guide, self-appointed, was obtained who occasionally proved useful. This work continued without interruption from July 24 to September 5. This region, being only about 2° north of the equator and at sea level, was considerably warmer than any locality previously visited.

The *Rhabdocnemis* found in sugar palms about Menado evidently attacks sugar cane rarely. The natives positively stated, in several instances, that this beetle bores in sugar cane sometimes. Only small patches of cane were found in Celebes, constituting usually a few stools in native villages. One stalk was found bearing old borer channels, but no cocoon or larval exuviae could be seen.

On the *Rhabdocnemis* in the Tateli forest a large Braconid pupal parasite was found (see figure). There were indications that it may also develop on the mature grub. This wasp has an ovipositor of from one-half to three-fourths of an inch in length, with which it is able to sting, paralyze and oviposit upon the borer grub or pupa. The egg is placed upon the body surface. The egg hatches in from 3 to 4 days, the small larva then feeding on the surface of the grub, rapidly growing and emptying the host of its body juices. Maturity is reached in about 6 days. A silken cocoon is spun within the borer cocoon and the adult wasp emerges in about 12 days more. This was under Menado temperatures with a daily average maximum in the hotel room of about 90° F. and a minimum of 75° F. The finding of this parasite, so different from anything yet uncovered, raised great hopes for its utilization since it attacked the pupa and should harmonize well with the larval parasite *Ceromasia* already in Hawaii. Such expectations were ultimately shattered, however, because of the great scarcity of this wasp. Only ten individuals were reared between August 1 and October 15, and only 2 were seen and caught in the forest. Never at any one time were more than 3



Braconid wasp, parasitic on pupa and mature larva of *Rhabdocnemis* in North Celebes.

living females available for cage breeding and they could not be induced to oviposit satisfactorily in captivity. A large cage was constructed for this purpose but only a few successful ovipositions were secured. The scarcity of this parasite was manifest by the collections and examinations of several thousand borer cocoons dug out of palm leaf stalks during residence in North Celebes. This Braconid must be under heavy suppression by natural enemies, though no secondary parasites were reared from the few parasitized borer pupae collected. The wasp has a slow, labored undeviating flight and must fall a ready prey for birds, certain predatory insects and even lizards, which abound. It may also possibly parasitize some other undiscovered Calandrid in the forest.

No other parasites were found; but predatory enemies almost identical with those shipped from the Philippines were abundantly present, especially the two egg-sucking bugs and the Leptid fly. Perhaps the most effective check of the borer in North Celebes is a fungous disease somewhat similar to the one found in Java, as mentioned above. Dead beetles, larvae and pupae were easily found bearing this fungus. Many were collected and used for inoculating a good quantity of living beetles and grubs. These became inoculated simply by contact with the powdery masses of spores on the dead ones. A high percentage, thus inoculated, died in from 6 to 10 days. This fungus was shipped to Honolulu and, as mentioned above, Mr. Barnum has succeeded in propagating it on *obscura* with high degrees of mortality. There is a bare chance that it may prove as effective in Hawaii as in Celebes, after a sufficient lapse of time for its distribution. Wet conditions favor its development and consequent spread, though it was found and collected in Celebes during the periodic six months dry season.

A week's trip was then made on a small Dutch steamer to various islands in the Celebes Sea extending north by east about 200 miles. Visits were made to the islands of Tagolanda, Siao, Sangir and the Talauer Islands. This region lies in a more or less direct line between the Molucca Islands and Mindanao Island in the Philippines. The islands are much isolated and each is surrounded by deep sea. No species of *Rhabdocnemis* were found on any, nor were suitable host plants present, such as sugar palms, sago palms and sugar cane, excepting in a few rare cases. The entire group is heavily planted to coconuts.

While on Sangir Island, opportunity was had to observe the complete destruction of several hundred acres of mature coconut trees by an introduced coconut pest *Aspidiotus destructor* Sign. As existence among the natives on this island depends almost entirely on their copra trade, they, and the one white inhabitant, a Dutch official, were much alarmed, for the insect was rapidly spreading from the one point of devastation. Time was had to examine some of these trees and to demonstrate the total absence of parasites or important predators. As a result, well known parasites of this pest, long known in Java, are now being sent to Sangir by Mr. Leefmans, of the Dutch Entomological Service.

The islands of Siao, Sangir and Tagolanda bear one or more great, smoking, semi-active volcanoes of tragic history in relation to the native inhabitants. Thriving native villages were encountered on the very slopes of these steaming, smoking cones.

Returning to Menado, the elevated interior of North Celebes was next visited. On Tondano Lake, at an elevation of 2250 feet, sago swamps were numerous along its borders. In these palms, an additional species of *Rhabdocnemis* was fairly common. Several thousand larvae, pupae and adults were examined, together with a fair lot of eggs. Only 3 more pupae were found parasitized by the same Braconid as in the Tateli forest near Menado. The predators, already referred to, were all present, and borers dead with the same fungus were common. The Menado species of *Rhabdocnemis* was also found in various places in the elevated interior in sugar palms; but no control factors other than those about Menado appeared. These results in the interior were disappointing, since every effort was made to find a locality where the Braconid parasite could be found in greater numbers than in the Tateli forest.

Returning again to Menado, a study of the *Rhabdocnemis* in sugar palms at Tateli and about Menado was taken up again. This continued until October 16, 1926. No encouraging indications were discovered of additional enemies to those already studied and nothing further was seen of the Braconid wasp.

While in North Celebes some time was spent in the examination of termites for natural enemies. No effective parasites were found, though in two cases, small workers of a species of *Termes* were found to contain the larva of a fly within the abdominal cavity. Many subsequent dissections revealed no more. Nematodes were found present in the mouth cavity of certain termites. In the small workers of a species of *Termes,* a nematode inhabiting the abdomen outside of the intestinal tract was frequently seen. There was no certain indication that these nema checked the termites to any marked degree. Shipments of these nematodes were made to Honolulu. Mr. Muir and Dr. Henderson have succeeded in developing a quantity of the intestinal nematode. They were placed with a colony of *Coptotermes* in the laboratory. Recent dissections of these termites showed no signs of nema infestation, however. The Celebes abdominal nematode is probably attached only to certain castes within a very limited group of termite species. None was found within *Coptotermes* in Celebes.

Departing from Menado on October 17, Macassar, the only city of Celebes worthy of the name, was reached in 5 days. The country for 40 or 50 miles around Macassar is flat and cultivated mostly to rice. The original forest was gone even in Wallace's time (1860). No sago swamps were found and only a few scattered sugar palms could be located and these were far from Macassar. When examined no *Rhabdocnemis* were present. This proved an unsuitable region to work in. The heat was intense and the whole country parched, dry and dusty, which probably accounted for the absence or scarcity of *Rhabdocnemis* in the palms at that time of year. No sugar cane was seen. A small forest reserve region on the Maros River, some 40 miles away, was located where termites could be found in abundance. Studies of these revealed nothing in addition to what was found in Menado.

Owing to infrequent steamship traffic between South Celebes and British North Borneo, it was necessary to remain in Celebes until November 18, when passage

was secured on a small Japanese freighter. This reached Sandakan, British North Borneo, November 22.

British North Borneo is largely covered with tropical forests. It is a region of abundant rainfall and rivers and small streams abound. Transportation is mostly by small steamers along the coast, and canoes, launches and motor boats on the rivers. No roads extend inland excepting one short road 11 miles in length from the small town of Sandakan. This road passes into forest country only a few miles from the town. For the most part North Borneo is in an undisturbed natural state and furnishes a happy hunting ground for the naturalist. Wild elephants have only in recent years caused consternation amongst laborers clearing the jungle within 8 miles of Sandakan, while crocodiles with a notorious and demonstrated esteem for human flesh, abound in the swamps and along the river banks in places. During the investigations described below, snakes of varied sorts and sizes, both poisonous as well as harmless, were frequently met with, especially forms which inhabit the foliage of trees, vines and shrubs.

The forests about Sandakan were immediately examined for palms. No sugar palms occur there and only small bits of sago palms were found on the east coast. No *Rhabdocnemis* were seen in this sago nor in the cultivated oil palm, *Elaeis guineensis* about Sandakan.

On November 28, transportation was secured on a small, 100-ton steamer to the north end of Borneo and to the island of Jambongan off the northeast coast. No palms were found at the north end of the island. Jambongan is inhabited only by natives. Examinations along the coast of this island, which is densely covered with forest down to the shore line, revealed neither sugar palms nor sago swamps.

Returning to Sandakan, transportation was again secured on this same boat around the north end of Borneo to the west coast where the small English town of Jesselton is situated. From this place a small railroad has been built along the coast through swamps and over many streams and rivers for the convenience of rubber planters. This railroad passes large sago swamps, some 20 to 30 thousand acres in extent. These natural swamps furnish ample carbohydrate food for the natives. The palm grows in standing, fresh water adjacent to the sea, forming a dense, almost impenetrable jungle 30 or 40 feet in height. By careful guidance on the part of two natives, these were safely entered and examined. A species of *Rhabdocnemis* was soon found in the thick leaf stems of these palms. The collection of a large quantity of borer material here indicated the absence of any parasites, and again the control factors seemed to be predatory insects of the same species or varieties found in the Philippines, Java and Celebes. No fungous diseases, however, were found on the Borneo borer. The egg-sucking Mirid and Anthocorid bugs, noted in the Philippines, Java and Celebes, predominated amongst the predators. Since nothing new was found in Borneo, no further shipments were made to Hawaii.

A short trip was made to the island of Labuan, off the northwest coast of Borneo. Sago swamps were found there but no *Rhabdocnemis* were discovered.

which is curious, considering its abundance in the swamps on the adjacent Borneo coast.

In the sago at Labuan and at Papar on the west Borneo coast, a fairly common, small Calandrid beetle (resembling *Diocalandra*) was found abundantly parasitized in the larval stage by a small Braconid wasp. This weevil is very much smaller than *R. obscura*. Attempts to breed this parasite on immature *Rhabdocnemis* larvae failed.

Returning to Sandakan on January 20, 1927, eleven days were spent in the forests nearby examining termites for parasites. Nematodes were commonly found in the mouth cavity of many termite species. Seventeen species in all were examined. Nema were present in most of them. None was found in species of *Eutermes;* but were abundantly present in two species of *Coptotermes,* the genus with which we are mostly concerned in Hawaii. In the case of one species of *Capritermes,* mounds were often found completely vacated. In attempting to explain this, the mouth-inhabiting nematodes were found in abundance in this species. Often a single head would contain as many as 20 active nema. A quantity of these infested termites was collected in the forest near Sandakan about January 27 and prepared for transportation to Honolulu.

Passage to Manila was secured on the Australian S. S. "Tanda" leaving Sandakan February 1. Five days were spent in Manila before departure for Honolulu.

Reaching Honolulu on March 3, it was found that the termite-nematodes, carried from Borneo, were still living. Many were present in the bodies of the termites which died in transit. All of the termites were dead. Dr. Henderson has examined this nematode and found it to be a species of *Rhabditis*. An experiment is now under way to infect *Coptotermes* with these nema. It is too early to know the results.

The accompanying illustrations of sugar palms in North Celebes are given to indicate their importance as a factor in the forests there. They form, in places, thickets of nearly solid stand. They are abundant and prolific in virgin forests not only in Celebes but in Sumatra, Java and the Philippines from sea level to 4,500 feet elevation. On Mt. Makiling, in Luzon, they do not thrive above 2,000 feet; but in the more tropical parts of the Malay Archipelago they extend much higher. The tree is hardy and seeds heavily. The sticky sap, tapped from the flowering stalk, is much cherished by the natives, wherever found, for its sugar content. This sap is collected in bamboo joints, boiled down to a point of crystallization and cooled into cakes and sticks of varying design, forming a delicate product equal or superior to maple sugar. This tree is well worth a trial in the lowland forests of Hawaii.

In conclusion, it should be stated that the general results of the expedition suggest, as originally felt by Mr. Muir, an Austro-Malayan rather than Indo-Malayan origin of *Rhabdocnemis obscura*. The regions visited were primarily selected beyond the territories concentrated upon by Mr. Muir, in order to avoid duplication of effort and to find, if possible, something entirely different in nature from the Tachinid parasite *Ceromasia sphenophori*. The scarcity or complete absence of true parasites of *Rhabdocnemis* in Java, Borneo, Celebes and the Philip-

pines, as compared with the abundant parasitism by *Ceromasia* in Amboina, Ceram and New Guinea, further strengthens this view. On these three islands, Mr. Muir records a borer parasitism of 25 to 90 per cent, 58 to 90 per cent and 56 to 87 per cent, respectively.

During the present expedition, though thousands of borer larvae and pupae were collected in each place visited, no parasites at all were reared excepting in the Philippines and in Celebes and in these cases the percentage of parasitism was exceedingly low.

In case the predatory insects and diseases above discussed and shipped to Hawaii from Java, Celebes and the Philippines, fail to become established and future investigations are made in the Malay Archipelago of *Rhabdocnemis* enemies, the Austro-Malayan territory should afford the best chances for success. This includes New Guinea and adjacent islands, the Bismarck Archipelago and the Moluccas. As insect collections from this great area become more extensive, it is quite possible that the genus *Rhabdocnemis* will be found richer in species there than in the Indo-Malayan region.

Thanks are due Mr. C. F. Baker, dean of the College of Agriculture, Los Baños, Philippine Islands; Mr. S. Leefmans and Dr. P. Van der Goot, of the Instituut voor Plantenziekten, Buitenzorg, Java; and to Mr. H. G. Keith, Acting Conservator of Forests, British North Borneo, for courtesies, advice and assistance. We are also especially grateful to Mr. O. W. Pflueger, Chief of Division of Investigations, Bureau of Forestry, Philippine Islands, for much assistance in the collection of forest tree seed and in the preparation of insect cases used in shipping beneficial insects from Los Baños to Honolulu.

Sugar palms, *Arenga saccharifera*, in background, at edge of forest, Tateli, North Celebes.

Sugar palms, *Arenga saccharifera*, in forest, Tateli, North Celebes.

Sugar palms, *Arenga saccharifera*, at edge of forest, Tateli, North Celebes.

Road passing through forest of mostly sugar palms at Tatelli, North Celebes.

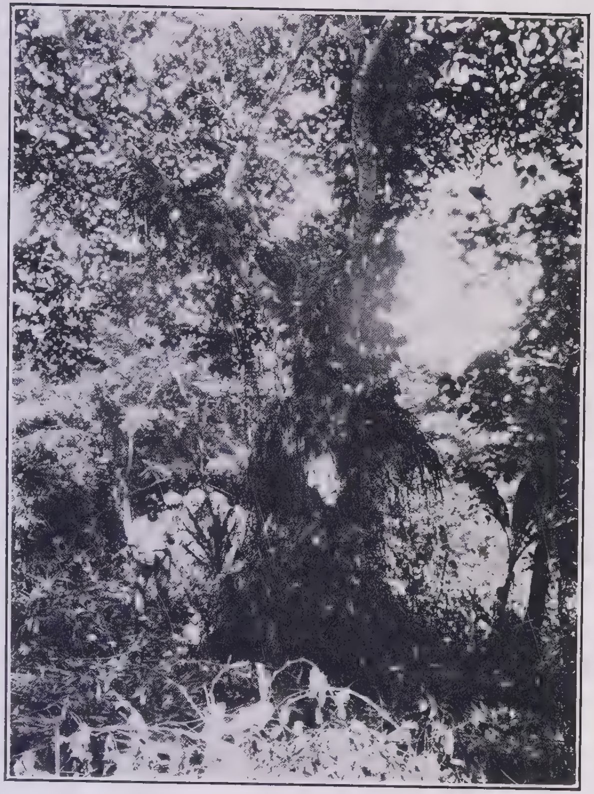
Sugar palms, *Arenga saccharifera*, in forest, Tatelli, North Celebes.

Typical disembarkation facilities at many points visited in the Dutch East Indies.

Littoral vegetation at seacoast, North Celebes.

Showing typical crown of *Ficus minahassae*, Mt. Makiling, Philippine Islands.

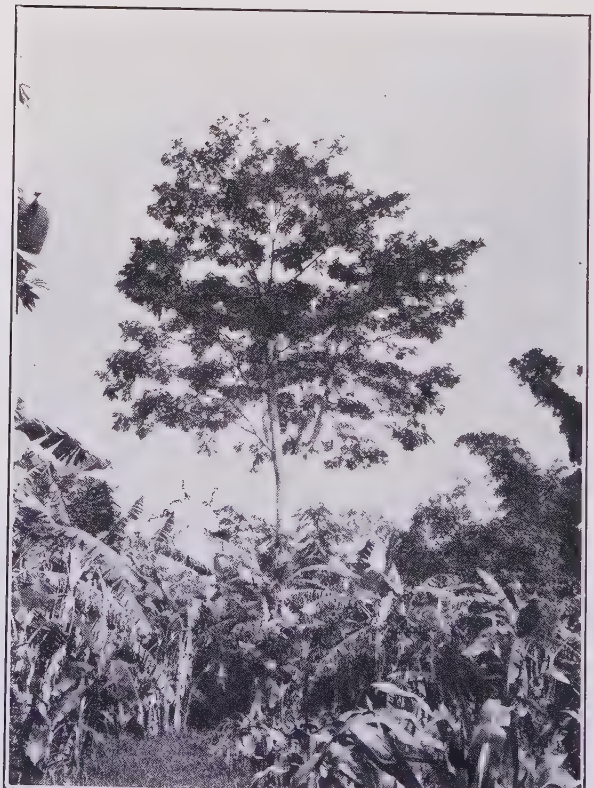
Ficus nota, at base of Mt. Makiling, Philippine Islands. Height 30 feet.



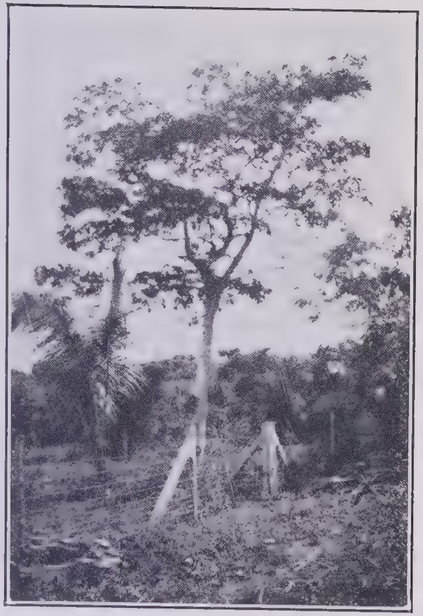
Ficus minahassae, Mt. Makiling, Philippine Islands.

Edge of forest, Mt. Makiling, Philippine Islands. Teak seedlings in foreground.

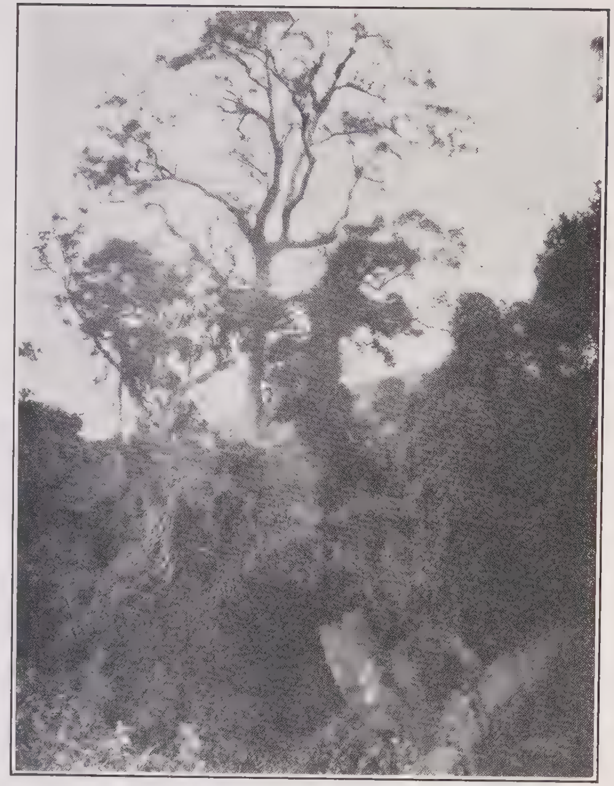
Mt. Makiling, Philippine Islands. Heavy forest extends to top.



Parkia timoriana, volunteer in cultivated land at base of Mt. Makiling, Philippine Islands.



Parkia timoriana, at base of Mt. Makiling, Philippine Islands. Trunk 2½ feet in diameter.



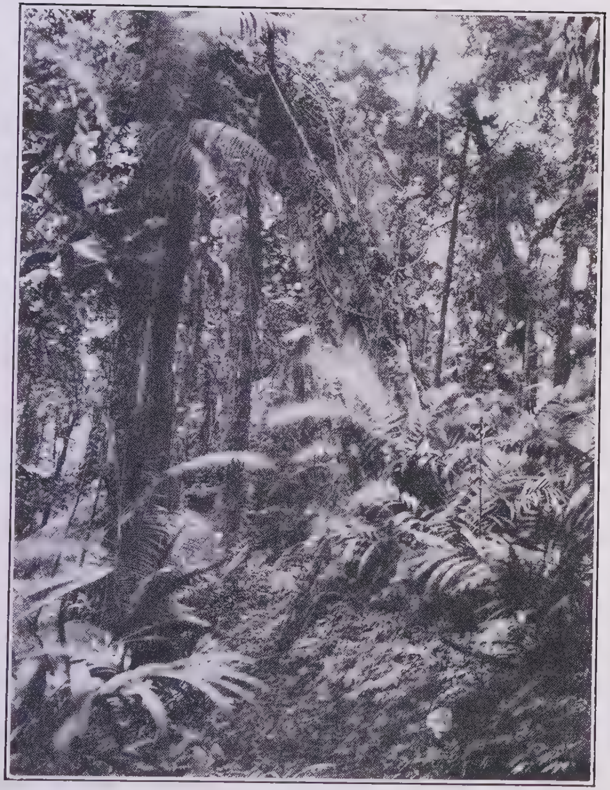
Parkia timoriana, at edge of forest, Mt. Makiling, Philippine Islands.

Base of giant *Ficus sp.*, Mt. Makiling, Philippine Islands. Elevation 1500 feet.

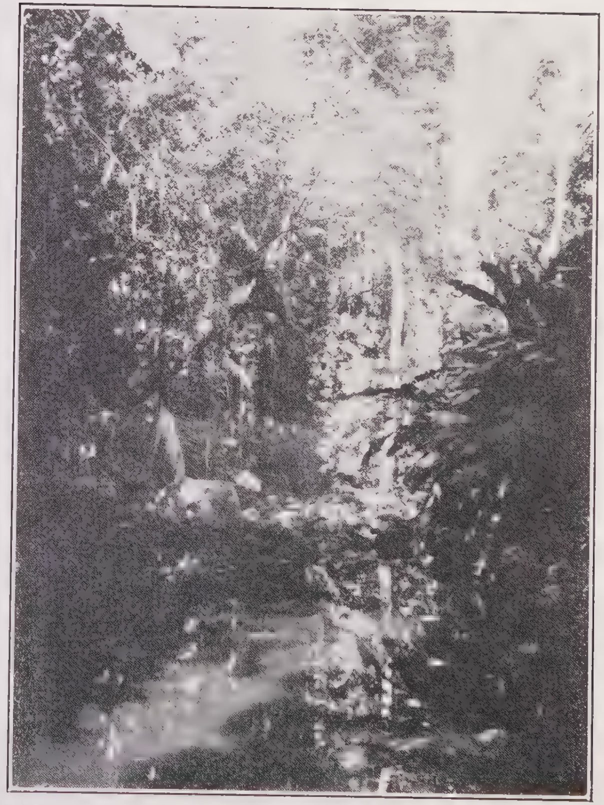
General forest conditions, Mt. Makiling, Philippine Islands. Elevation 500 feet. Giant *Parkia timoriana* in foreground. Diameter of trunk is five feet.

Large *Ficus sp.*, Mt. Makiling, Philippine Islands. Elevation 1500 feet.

Typical forest conditions, Mt. Makiling, Philippine Islands. Elevation 1500 feet.



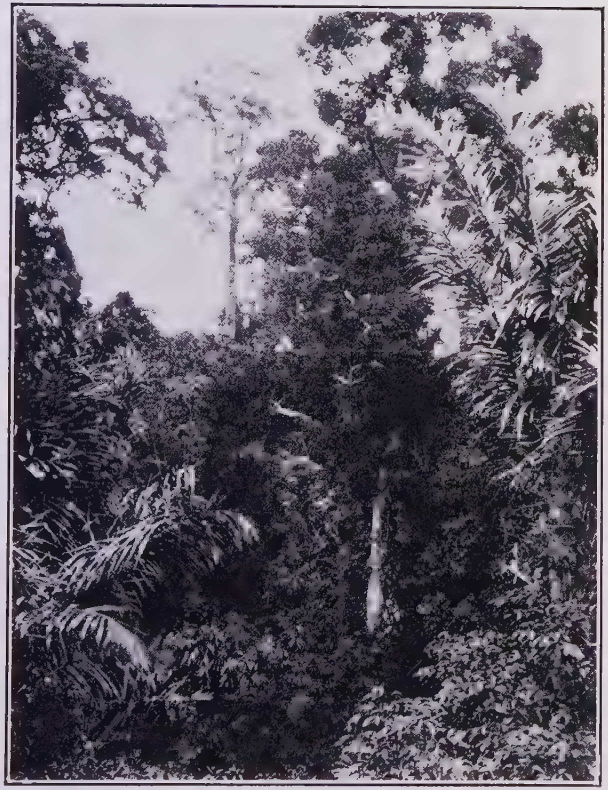
Typical forest conditions, Mt. Makiling, Philippine Islands. Elevation 2000 feet.



Molawin River, Mt. Makiling, Philippine Islands. Elevation 300 feet.

Typical forest conditions at 2500 feet elevation, Mt. Makiling, Philippine Islands.

Edge of forest, at base of Mt. Makiling, Philippine Islands.



Edge of forest, Mt. Makiling, Philippine Islands.

Avenue of *Canarium commune*, Botanic Garden, Buitenzorg, Java.

Buttressed trunk of *Ficus cordifolia*, Botanic Garden, Buitenzorg, Java.

Losses From Mosaic
Kohala Sugar Company, Experiment No. 1

By J. A. Verret

One of the better known Kohala seedlings is Kohala 202. This cane shows promise as a good producer for medium and mauka elevations.

Kohala 202 has one unfortunate weakness in that it takes mosaic rather readily.

So it was determined to test out the effect of mosaic on the yields of this variety. With the cooperation of the Kohala Sugar Company a test was laid out on that plantation. Four plots were used. Two of these plots were planted with carefully selected healthy seed, and two were planted with seed from mosaic plants. All the primary shoots from the diseased seed showed mosaic in early growth, while no mosaic was present in the healthy plots in the beginning, but at harvest it was found that several stools had become infected. On the other hand, several stools in the diseased plots were found free of mosaic. Apparently these stools had recovered from the earlier infection.

The cane was harvested in February, 1927, when the cane was 18 months old.

The results are given below:

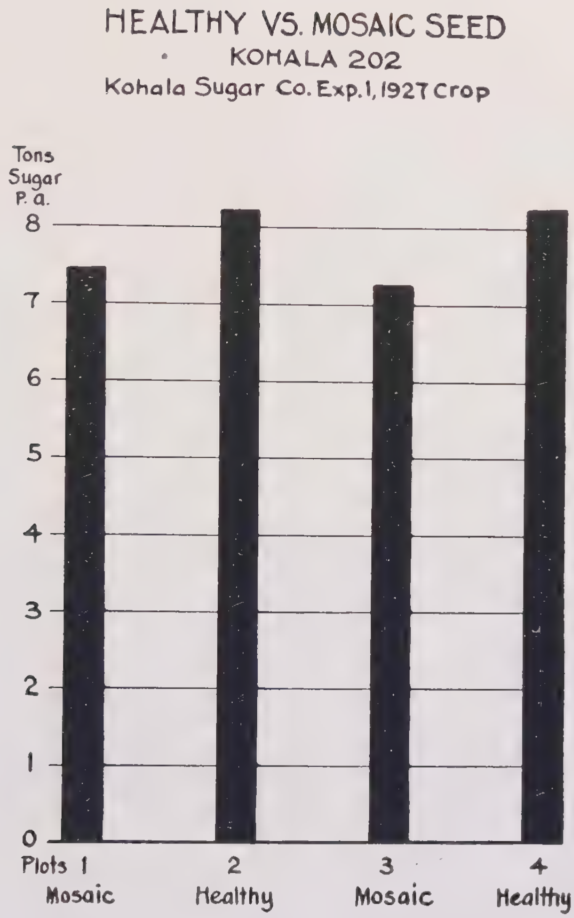
YIELDS

Plots	Area	Tons Cane	T. C. P. A.	Q. R.	T. S. P. A.
1—Mosaic	.0439 ac.	2.418	55.1	7.38	7.46
2—Healthy	.0459	2.654	57.8	7.02	8.23
3—Mosaic	.0444	2.386	53.7	7.38	7.27
4—Healthy	.0385	2.238	68.1	7.02	8.27
Average Mosaic			54.4		7.34
Average Healthy			57.9		8.27
Difference in favor of healthy			3.5		.93

JUICES

	Brix	Pol.	Purity	Q. R.
Mosaic	19.62	17.77	90.6	7.38
Normal	19.72	18.36	93.1	7.02

You will see from these results that the diseased seed plots produced 0.93 ton of sugar per acre less than did those planted with healthy seed. This is a loss of about 11 per cent when the field is approximately 100 per cent infected. Most of our other cane varieties would show larger losses than this with complete infection. K 202 is very tolerant of the disease, but on the other hand, as before remarked, it contracts the disease very readily and unless due care is exercised plantings of this variety would soon be heavily infected.



The best methods of control for mosaic have been found to be the following:

1. Very careful inspection of all seed while cutting in order that only healthy seed be planted.

2. Roguing. This consists of periodic inspections of the field and the digging up of all diseased stools found. It is not necessary to burn or take away these destroyed stools. They do no harm when allowed to remain on the field.

3. Clean culture. Mosaic is transmitted by the corn aphid. This insect prefers many of the grasses to sugar cane and is more likely to be found in cane fields where grasses are than in clean ones. Many of these grasses get mosaic. This is the reason mosaic is more likely to be found along the edges of fields, along ditches and roads where grasses are growing.

The Brown Australian Lacewing
(*Micromus vinaceus*)

By Francis X. Williams

The brown Australian lacewing was brought into the Hawaiian Islands in August, 1919, to help destroy the various plant-lice, particularly those affecting the sugar cane and corn plants. Though apparently a frail insect it readily became established and is now found, in suitable localities, on the four principal islands of the group. It has proved a useful if rather inconspicuous insect and is usually present wherever there are aphis infestations.

Micromus vinaceus belongs to the order Neuroptera, and to the family Hemerobiidae, or brown lacewings. As an adult it has quiet and probably nocturnal habits and a wing expanse of about a half inch. It is not, however, very bent on flying, and when at rest, with the wings held steeply roof-like over its back and the long beadlike feelers extended forward and close together, is not readily seen, the less so when on some dead leaf which it resembles in color. Often when disturbed it will fall over on its side and thus seek safety in playing possum.

During July, 1919, while working in the sugar cane district near the town of Halifax, on the Herbert River, North Queensland, Australia, the writer caged, among other beneficial insects, a number of this little lacewing with some of its aphis prey, and of these succeeded in bringing fourteen alive to Honolulu. From these few *Micromus*, thousands were reared through many generations, into the following year.*

The eggs of *Micromus* are devoid of the long pedicels found in those of its relatives, the larger and frequently ill-smelling green lacewings (*Chrysopidae*); they are oblong cylindrical and deposited in groups along their long axis, one egg often touching another; they measure about ¾ x ⅓ millimeters and bear a small knob, the micropylar area, at the opaque end. The color is a sort of pale iridescent carneous. Viewed under high magnification the surface exhibits a design of fine network. Captive *Micromus* never oviposited on the glass sides of their prison, rarely on the green leaves of the sugar cane, but commonly upon cloth or cotton. A single mated female deposits a large number of eggs, but must be well fed to secure optimum results; in one case a specimen commenced laying on the third day after emerging from the cocoon and laid 558 eggs for her lifetime of thirty days, oviposition continuing until the day of her death; another specimen in her life of twenty-one days laid 619 eggs during eighteen days.

The eggs hatch in about three days, the larva making a more or less longitudinal slit at the micropylar end, and in crawling out regularly leaves the outer membrane or serosa that enveloped it within the shell, partly hanging from this slit. Freshly emerged, it measures nearly two millimeters long—having been curled up in the egg—and tapers fusiform from near the middle of the body to either

* P. H. Timberlake, formerly of this Experiment Station, did some of this breeding work.

end; the tail especially being slender; the thorax is furnished with three pairs of legs, and in addition, the posterior extremity of the body is also used leg-like, in aiding locomotion. The head is rather polished, darker at the sides, and bears slender feelers, mouth palps and a strong pair of rather curved and pointed mandibles and maxillae; the larger palps, the antennae and legs in part are smoky blackish; the color of the body as a whole is very pale brown, the intestine showing through as a darker shade; while there is evidence of creamy white markings on the thorax. In addition, there is a clothing of rather sparse dark hairs.

This, the first stage larva commences feeding very soon, and when in captivity and doubtless also when at large, does not hesitate to make a meal of an egg or two of an unfortunate brother or sister that failed to hatch so quickly. Piercing the delicate egg shell with the tips of its jaws it sucks the contents through the imperfect tube formed by the mouth parts, it pushes these a little deeper within, then withdraws them somewhat, or it may twist the head slightly from side to side; this sawing action probably assists in absorbing the content of the egg, the latter soon collapsing. More normally, this dragon-like creature wanders about seeking aphids and perhaps other small bugs, and mites.

The day following its birth (in the single case noted) it sheds its skin to become a second stage (or instar) larva; it first glues its tail fast to some object and when ready for the moult pulls itself out of the loosened skin. It is now about four millimeters long, with the markings more pronounced and extended than in the first stage. After further eating, its skin again becomes too tight for it and the second moult takes place, in the case tabulated, on the day following the first moult. Such a last stage larva a few hours old is about six millimeters in length and marked as follows: the tips of the antennae are whitish, the legs from their origin to the base of the tibial part and the extremity of the tarsi are blackish; the body in general is of a dull purplish color, blackish in the middle and at the tail end, the first part of the thorax with a pinkish white stripe at the sides, and the latter half of the third segment of the thorax has a split band of whitish color on the back, while the last five abdominal segments but one bear a broken stripe of this color along the sides, but showing also, though more faintly, on the back where it is divided by the dark line of the dorsal blood vessel.

In its four days or so of active life as a larva, *Micromus* feeds voraciously. Unlike the larva of certain green lacewings it does not adorn its body with a protective covering of the skins of its dry-sucked victims, but runs about naked and comparatively defenseless, and we must attribute its success in the struggle for existence, in great measure, to the large number of eggs laid, over a relatively long period, by a single female. As observed in captivity one larva will readily devour another of its kind and occasionally we see a specimen whose curtailed posterior extremity would indicate bare escape from the jaws of one of its hungry fellows. A larva on the move sways the head from side to side in jerky fashion and feels its way or, its food, by means of the downward-pointing palpi; when it encounters another *Micromus* larva, it will often jab or peck at it with open jaws, the offended relative retaliating with blows from its tail; sometimes two will unwillingly share an aphis but one will eventually pull the morsel away from the other. When an aphis is encountered it may or may not be seized immediately, *Micromus* will palp it perhaps, or make cautious digs at it with open mandibles sometimes thus piercing it; the homopteron thus apprised of its peril becomes very agitated; it may beat a retreat or sway its uplifted abdomen and exude a darkish liquid from the tubular processes near the end of the body. After such and additional preliminaries, *Micromus* deeply stabs its victim, commences sucking immediately and bracing itself pulls its prey off the leaf and raising it aloft soon converts the unfortunate bug into a collapsed sack. While thus feeding, the antennae and palps are held clear of the aphis.

With plenty of food available the Hemerobiid attains full growth within two days of its second moult and now chooses a place, such as the concavity of a leaf surface in which to spin the delicate mesh-like cocoon. Silk-producing apparatus in by far the greater number of insects consist of glands that unite as a common duct opening at the mouth parts. Such are the spinning glands of the silkworm of commerce and of other moth caterpillars. A notable exception in the location of such organs is to be found in the family Embiidae, composed of a relatively small and rare group of termite-like insects that spin a web with their fore paws, the gland ducts in this case opening through hollow bristles. And perhaps an equally strange allocation of silk glands occurs in the larva of the brown lacewing and in many other more or less closely related neuropterous insects, for here a portion of the Malpighian tubes (comparable in general function to the kidneys of vertebrates) becomes modified into silk glands, so that the insect employs its tail as a spinner. Two transverse parallel silken sheets are formed some millimeters apart and between which the oblong spindle-shaped cocoon proper is spun; it is quite fragile—merely an open meshwoork of pale silk with little dew-like thickenings along the strands—and conceals but slightly the larva or later, the pupa. The length of the cocoon proper is about five millimeters. It now encloses a larva that in preparing to form a pupa assumes a pupa-like pose, lying quietly with its head bowed down, its legs over the breast and its posterior extremity curved forward rather hook-like; in this unextended posture it measures about 3.75 millimeters long. In due time this, the third larval skin, is discarded, and lies shrivelled

near the end of the freshly formed pupa. The pupa is carneous and whitish in color, except for the glassy, milky transparent appendages, the eyes and tips of the mandibles being dark, and it rests, thinly clad in long pale hairs, in a huddled pose, the appendages, however, being freely moveable. It is fairly active when disturbed and yet more so at the last, for it then bites its way out of the delicate network, crawls on top of the cocoon or beyond it, the skin splits along the back of the thorax and the adult *Micromus* is disclosed. Soon its wings attain their proper length and strengthen with the rest of the body so that in a few minutes it is fully mature.

The entire life-cycle—from the laying of the eggs until the hatching of the adult—may not occupy more than two weeks, so that under favorable conditions the insect multiplies rapidly. The adults are very quiet in captivity and themselves devour a great quantity of aphids; in one case, the female of a freshly emerged pair ate fifteen aphids in ten minutes, her mate consuming thirteen in seven and one-half minutes. They were observed to wash or brush their faces with the forepaws.

The brown lacewing was reared in the laboratory in Honolulu for a full year after its introduction from Australia, the first adults being liberated at the Waipio substation, Oahu, on September 17, 1919, while the last lot, which included the seventeenth generation, was released on the H. S. P. A. Experiment Station grounds on August 27, 1920. Records show that approximately 5,200 adult *Micromus,* besides a quantity of eggs, were distributed in the cane fields of Kauai, Oahu, Maui and Hawaii, and where they were later recovered.

Further Notes on Stem Galls of the Sugar Cane

By H. L. Lyon

In a paper published in *The Hawaiian Planters' Record* for October, 1926, the writer described a disease of the sugar cane, the one striking symptom of which was the appearance of overgrowths or galls on the stem. It was pointed out that this disease had been known to occur sporadically in the cane fields of these Islands since 1910, but that it had not assumed alarming characters until 1925, when it appeared in epidemic form in the canes on the Makiki Plots of this Experiment Station.

In the paper referred to, we list 74 varieties of cane on which galls had been found at the Experiment Station. A few of these canes were dug out and destroyed during the late months of 1926, but the majority were carried through into 1927. Seventeen additional canes in the 25 Q series, numbers 1, 7, 11, 18, 27, 70, 75, 119, 124, 150, 156, 158, 159, 162, 167, 188, 214, developed galls before they were cut in 1927. Galls also appeared on several plants of U. D. 1.

During the early months of 1926, 3,467 seedling canes from the 1926 sowings were planted out at the Makiki Plots. During the early months of the present

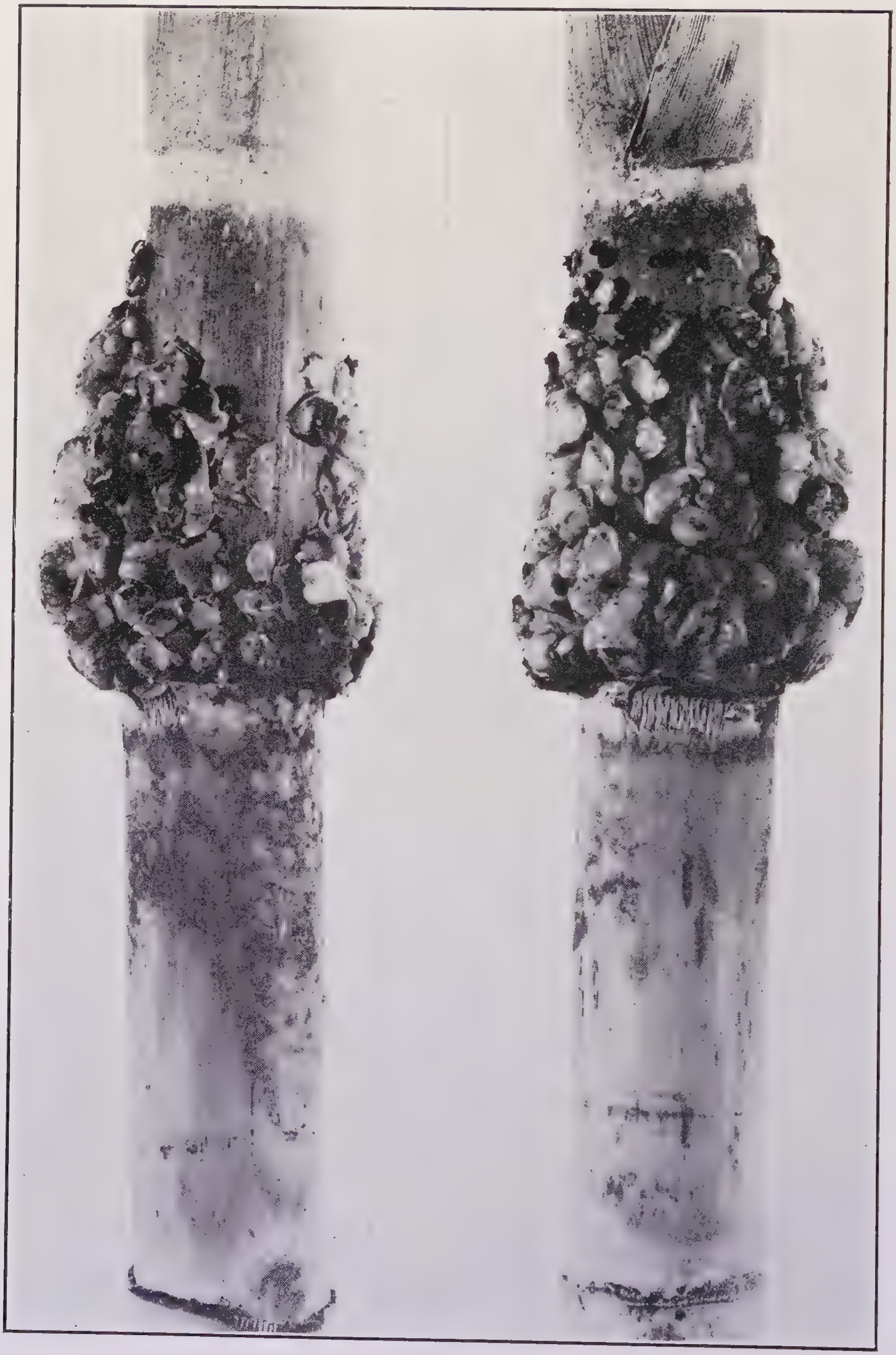


Fig. 1. Stem galls on 25-Q-27. Two views of the same internode. Photo by Twigg Smith.

year, these seedlings were subjected to a first selection for the isolation of the promising varieties. Two plots carrying 728 seedlings were cleared without any data on the occurrence of galls being recorded and, in some of the other plots, many of the poorer seedlings were eliminated before note was taken of the presence or absence of galls on their sticks. When a survey was made of the seedlings still standing, galls were found on 312. The exact number of seedlings examined was not recorded, but it was most certainly less than 2,739, so we know that at least one out of every nine of these 1926 seedlings contracted the gall disease during its first year's growth. It is obvious that the epidemic of 1926 carried over into 1927 with an ever-increasing momentum.

About the first of the year, galls of large size were found to occur in abundance on sticks of U. D. 1 growing in the recently developed experimental plot on lands belonging to the Mid-Pacific Institute. An examination of all of the canes made by Messrs. Das and Jain showed that the disease had appeared on many of the other varieties and on some in a very aggravated form. There were 32 U. D. varieties planted in this field, and galls occurred on 16 of them, among the latter being the 8 varieties named hereafter which were not included among the diseased canes listed in our former paper: Numbers 1, 9, 10, 17, 26, 85, 97, and 104. In a small block of D 1135, 42 per cent of the stools showed galls. Sticks bearing galls were also found in the plantings of Badila, Striped Mexican and P. O. J. 979. The Tip cane in its varieties, Striped and Yellow, occupied more space in the field than any other cane and, in fact, stools were growing next to those of every other variety; yet, not a single specimen bearing galls could be found although they were most diligently sought after. Likewise, no symptoms of the disease were detected in H 109, Lahaina, Yellow Caledonia, Uba, H 8965, H 89102 and U. D. 110, each of which occupied relatively large blocks. The disease was also absent in small blocks of P. O. J. 36, P. O. J. 213, P. O. J. 234, Manoa 300 and U. H. 1.

From the above survey, it will be seen that galls were found on sticks of 20 of the 49 cane varieties planted in the Mid-Pacific Plot. The prevalence of the disease in this plot and the aggravated form which it took on some varieties—notably U. D. 1, U. D. 13, and U. D. 25—caused much concern and, in February, 1927, the plot was declared quarantined and no canes have since been removed from this area for planting elsewhere.

Mr. Das reports the finding of galls on sticks of 20 different varieties of the U. D. series growing at the Manoa substation. Number 1 is included in his list, as are also numbers 16, 41, and 59, which have not been reported as diseased in other plantings.

Galls have been found on several occasions at Waipio, but, according to our information, they did not occur in an aggravated form in any case. Galls were detected for the first time on U. D. 58 at this substation.

At the Pathology Plot on the corner of Alexander and Bingham Streets in Honolulu, large galls were found by Mr. Muir on two stalks of H 109 growing from a cutting which had been planted seven months previous. These galls were well below the surface of the ground and were only discovered after the stool had been

Fig. 2. Folioids or wing galls on U. D. 13. Enlarged about 8 diameters. Photo by Twigg Smith.

dug out for the purpose of examining its roots for the occurrence of nematodes. A careful search revealed no galls at any other point on the several sticks in this stool.

From several plantations, we have reports recording the appearance of galls in fields of U. D. 1, Makaweli 1, H 109, and D 1135. Galls have also been detected on several plantations in experimental plantings of canes belonging to the U. D. and 25 Q series.

At Grove Farm, on Kauai, galls were noted for the first time on five canes of the 25 Q series as follows: Numbers 16, 23, 89, 128, and 151.

The outline as given above of the occurrence and distribution of this gall disease on our sugar cane is, by no means, exhaustive, but it should serve to indicate that the disease is becoming widely distributed in these Islands.

Galls and Knife-cut

Our observations have demonstrated beyond a doubt that the production of transverse cracks in the stem may be induced by the gall disease. (See Figs. 3 and 4.) This particular type of lesion has been previously noted in cane literature under the term "knife-cut," but it has not been considered a symptom of the gall disease. The term "knife-cut" is quite descriptive of the lesion, for it looks as though a transverse incision had been made in the stem with some sharp instrument after which the cut edges pull apart, leaving a gaping wound. Knife-cut accompanies gall production in many varieties of cane, but is much more exaggerated in some than in others. In some varieties, the incisions are never long, extending at most not over a quarter of the way around the stem. In other varieties, the knife-cuts will be numerous and deep, commonly extending a third to a half way around the stalk and occasionally one may be found completely girdling the stalk.

These extensive and deep knife-cuts greatly weaken the stems and the stalks so afflicted frequently break off through the knife-cut. Several of our seedling varieties of cane, upon contracting gall disease, showed the knife-cut lesions in great numbers and in exaggerated forms. The seedling 25-Q-88 was very badly afflicted with galls and also showed knife-cut at frequent intervals throughout the length of its sticks. In a very large stool of this variety growing in the interior of a block of cane, we counted twenty-two sticks which had broken square off 2 to 4 feet above the ground, each stick breaking through a knife-cut.

Galls and Bunch-top

In our former paper, we stated that bunch-top is quite often associated with the stem gall disease and we offered the opinion that it was due to the same causal factor. Competent observers here in Hawaii have expressed some doubt as to the soundness of this conclusion and it has also been questioned by Mr. D. S. North of Australia, as may be learned from his letter which we shall quote further on in the present paper.

Fig. 3. Galls and knife-cut on sticks of 25-Q-137. The galls are most numerous on the internodes, and the knife-cut lesions are confined to these regions. Photo by E. L. Caum.

Fig. 4. Additional examples of galls and knife-cuts on 25-Q-137. Photo by Twigg Smith.

During April of this year, the manager of the Hawaiian Commercial and Sugar Company called our attention to the fact that bunch-top was very prevalent in certain fields of H 109 at Puunene. A careful examination of many of the sticks bearing this bunch-top showed that they did not carry galls at any other point throughout their entire length. Frank Broadbent, who accompanied us in the field, expressed adherence to our former conclusion that "bunch-top is a mal-growth resulting through the abortion of an inflorescence or tassel." The specimens examined by us in the field offered strong evidence in support of this view, for in every case, seven or eight nodes below the bunch-top did not bear any eyes. It is a well known fact that sticks of many varieties of cane always stop producing eyes on their nodes for a short time before they shoot up the tassel. It is quite possible that bunch-top is, in many cases, an aborted tassel, but the question remains, what causes the tassel to abort and become transformed into this particular type of gall. As bunch-top occurs very freely in canes afflicted by the gall disease, it seems reasonable to at least suspect that it may be induced by the same cause. While this problem cannot be solved at the present time, still its ultimate solution is of considerable interest and importance. If bunch-top is a symptom of the gall disease, we can speak with more assurance regarding the history of the gall disease in Hawaii, for authentic cases of bunch-top were recorded in these Islands several years previous to the known appearance of typical stem galls on our canes.

Galls and Cane Varieties

The reactions of various varieties of cane to this gall disease are strikingly different. In fact, it is possible to identify many of the varieties by the type of gall which they produce and the distribution of these galls upon their stalks. U. D. 30 produces a mass of gall tissue which arises almost entirely from the root band. This gall tissue often forms a corrugated collar entirely encircling the node, as shown in Fig. 5. We have never found any galls on internodes of this variety. The variety 25-Q-137 suffers very seriously from the gall disease, but the galls are far more numerous on the internodes than they are on the nodes. In fact, a root band is often found quite free from galls when the internode directly above it is covered with a mass of galls. Although 25-Q-137 produces galls as freely as any variety yet examined, we have never, as yet, found an adventitious bud arising from its galls. All of its galled sticks—and these were all of its sticks in our cultures—showed numerous knife-cuts (see Figs. 3 and 4). It was early evident that this variety was rendered worthless by the gall disease and it was among the canes eliminated from our cultures at Makiki in 1926.

Some remarkable instances of localization of gall tissue are displayed by the varieties 26-Q-3127 and 26-Q-3214, which are illustrated in Figs. 6 and 7. In both of these varieties, gall tissue was produced in abundance, but only around the base of the lalas. The seedling 26-Q-2673, illustrated in Figs. 8 and 9, showed an interesting condition in that it produced large nodular (raspberry) galls on its internodes. The fact that it produced nearly spherical galls instead of the more common flattened ones found on most varieties is possibly due to the fact that it

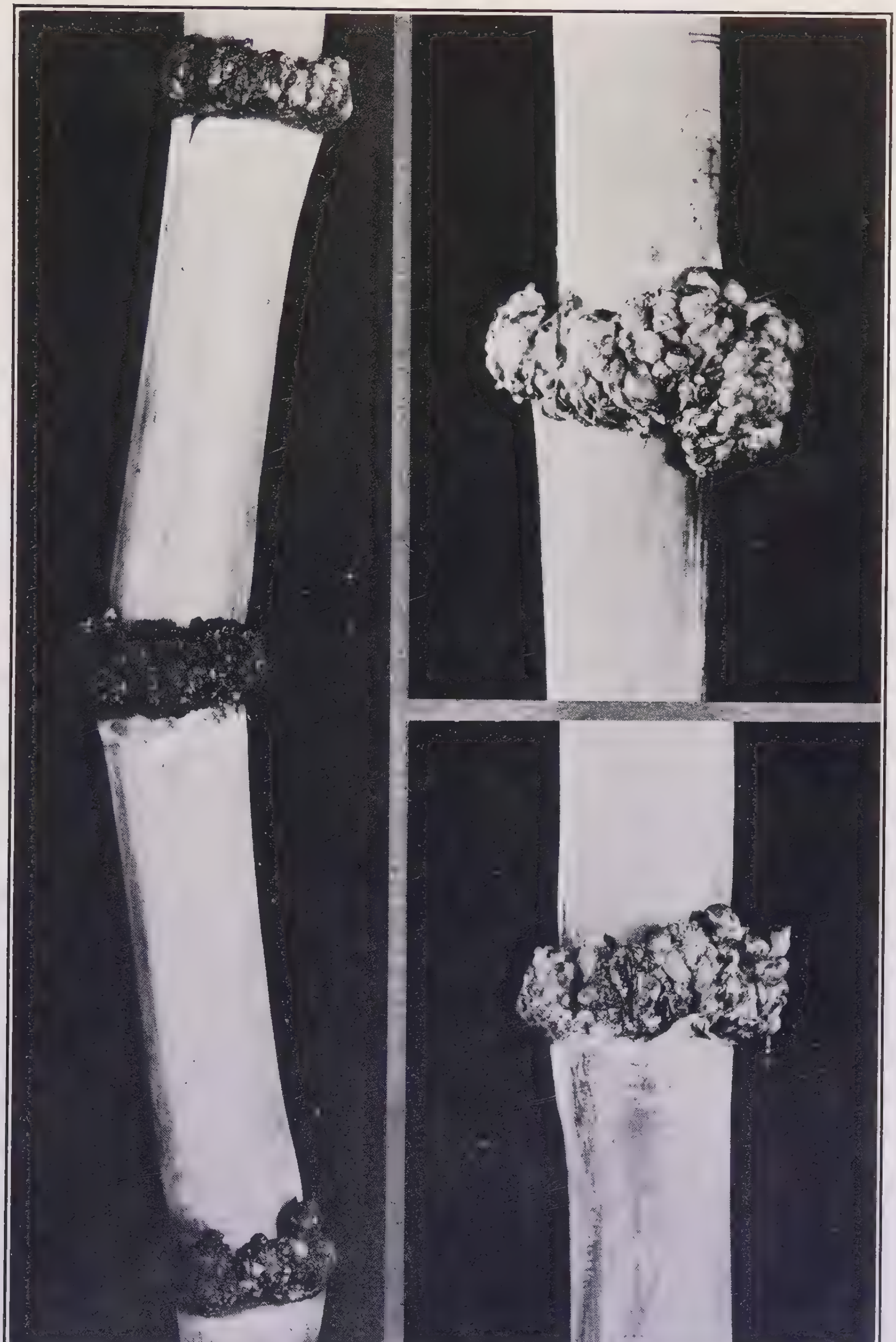


Fig. 5. Galls on U. D. 30. In this variety the adventitious growths are confined to the nodal regions. Photos by Twigg Smith.

Fig. 6. Tumor at the base of a lala in 26-Q-3127, somewhat enlarged. Photo by E. L. Caum.

Fig. 7. Tumors about articulations between lalas and stalk in 26-Q-3214. Photo by E. L. Caum.

Fig. 8. Nodular or raspberry galls on a stick of 26-Q-2673. Photo by E. L. Caum.

Fig. 9. A portion of the stick shown in Fig. 8, somewhat enlarged. Photo by E. L. Caum.

produced lalas very freely and these forced out the leaf sheaths at an early stage in the growth of the stick, thus relieving the gall tissue somewhat from the pressure of a closely adhering leaf sheath.

The imported cane P. O. J. 979, growing at the Mid-Pacific Plot, has also developed typical raspberry galls. In most cases observed, these galls occur on one or both sides of a normal eye, as shown in Fig. 10. As can be seen from this picture, they arise from node tissue.

Seedling U. D. 47, which supplied most of the illustrations of stem galls used in our former paper, has been grown in quarantine with the idea of seeing what will eventually happen to this variety as a result of the disease. We have had no difficulty in keeping this cane alive, but every stalk shows galls and many sticks are a veritable mass of galls throughout their entire length. The galls on this variety produce adventitious buds very freely and single joints often bear as many as twenty-five lateral shoots. The development of numerous long, thin galls on a leaf base, as shown in Fig. 11, is not uncommon in this variety. A few cases of galls on leaf bases have been noted in other cane varieties, but up to the present time, galls of the type with which we are now concerned have never been found on the blade of a cane leaf.

Because of the remarkable showing which U. D. 1 has made in field trials in several localities, the reactions of this variety to the gall disease are of special interest.

Galls were noted on U. D. 1 in 1925 and 1926, but they were never so numerous or of such an aggravated nature as to arouse much concern for the future of this variety. Early in 1927, however, it was discovered that the U. D. 1, growing in the Mid-Pacific Plot was heavily infested with galls and that in many cases, these galls took the form of very large tumors developing at, or just below, the surface of the ground. (See Fig. 12.) The sticks bearing these underground tumors were easily broken off by a fracture through the tumor. A careful survey of the U. D. 1, growing in the Mid-Pacific Plot, made by Messrs. Das and Jain, showed that out of a total of 188 stools of this variety only three were apparently free from galls and these three stools were composed of young shoots only, and consequently had not yet reached a stage where galls might be expected to show. Sticks of U. D. 1 often show an extensive development of galls on their aerial portions, as shown in Figs. 13 and 14. These galls appear on both nodes and internodes and are mostly of the folioid or winged type. That rank, succulent growth favors the production of galls is well illustrated in a large block of U. D. 1 in the Mid-Pacific Plot. The canes in certain rows in this plot were fertilized and irrigated, while the canes in alternating rows were neither fertilized nor irrigated. The favored canes are large and succulent and bear many galls, while the canes in the check plots are stunted, their sticks hard with the galls arrested at an early stage in their development.

The nine stools of U. D. 13 in the Mid-Pacific Plot all show galls in great abundance. The sticks of U. D. 25 have produced large underground galls which proliferate very freely, converting the stool into a compact mass of closely set shoots.

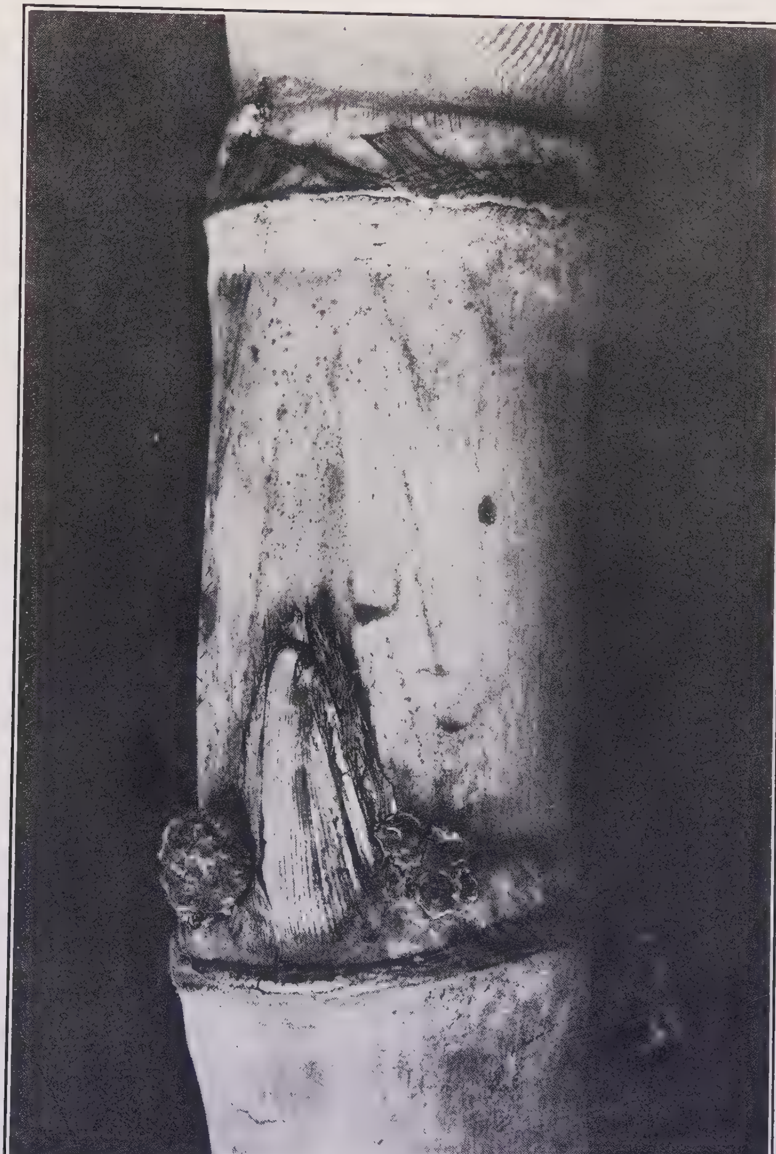


Fig. 10. Nodular or raspberry galls on a stick of P. O. J. 979. Photo by Twigg Smith.

Fig. 11. Galls on the leaf sheath of a lala of U D. 47. Photo by Twigg Smith.

Fig. 12. Large tumor at the base of a stick of U. D. 1. Photo by E. L. Caum.

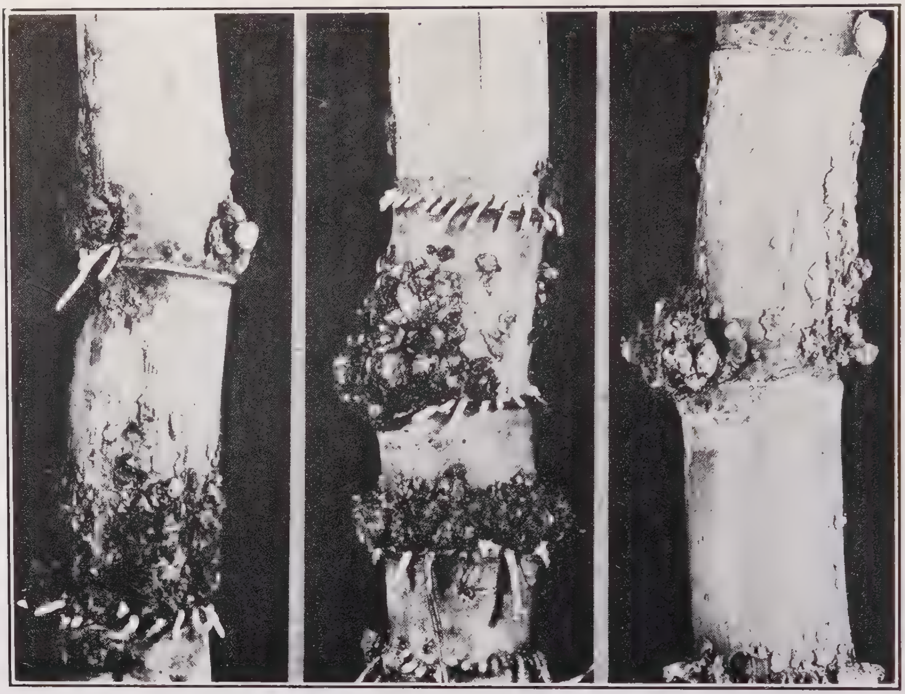


Fig. 13. Galls on sticks of U. D. 1. Photo by Twigg Smith.

It is becoming quite evident that D 1135 is susceptible to the gall disease, but carries it without displaying conspicuous symptoms. In February of the present year, Mr. Muir asked our opinion on a couple of specimens of D 1135 cane, which had been sent to him from Kauai by R. H. Van Zwaluwenburg. Mr. Van Zwaluwenburg reported that his attention had been called to this cane by the manager of Grove Farm, who had observed that many apparently healthy sticks of this variety were breaking off near the ground for no apparent reason. An examination of the specimens sent in by Mr. Van Zwaluwenburg showed that the sticks had broken off through a knife-cut. The writer suspected that this knife-cut was associated with gall production and made a trip to Kauai to investigate the matter. Broken down sticks were found in considerable numbers in certain areas and in all cases examined, the breaks were through knife-cuts, which occurred within a few inches of the surface of the ground. Typical galls were found on many of the sticks bearing knife-cut lesions. These galls were usually most numerous on the same internode with the knife-cut and often involved the same tissue. The galls were, in all cases, quite small, being arrested at a very early stage in their development. It is evident that the tissue of D 1135 strongly resists the influence which induces gall production. A curious, anomalous growth which we noted on sticks of D 1135 showing knife-cut was the occurrence of roots arising from the internode a short distance above an eye. These roots always took their origin in the eye groove and usually occurred at the apex of the groove, just a short distance below the wax band. In most cases, they were all hard, horny

Fig. 14. Enlarged view of a section from one of the sticks of U. D. 1 shown in Fig. 13. Photo by Twigg Smith.

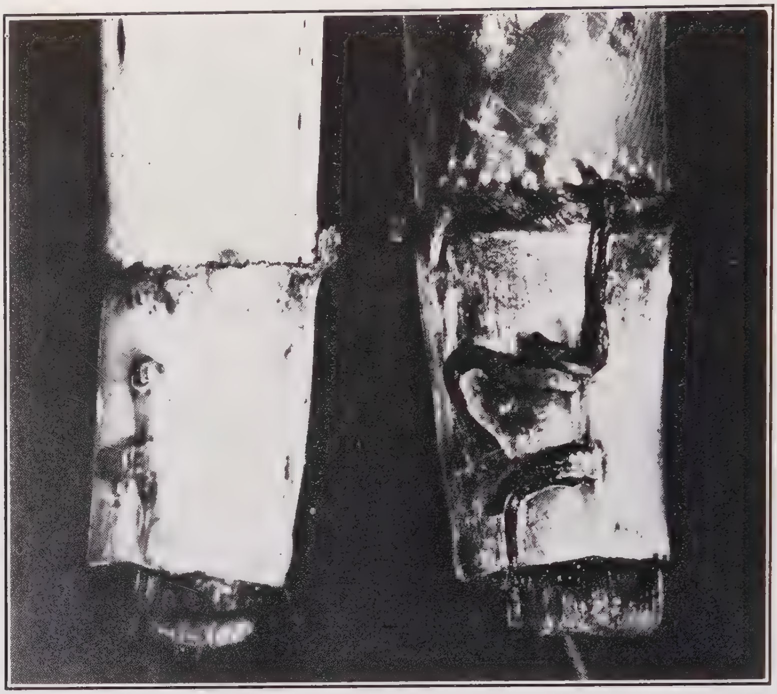


Fig. 15. Sticks of D 1135 from Grove Farm Plantation which broke off through knife-cut lesions. Both sticks showed adventitious roots and numerous small galls on the internode in which the knife-cut occurred.

protuberances, not over an eighth of an inch high, but several specimens were found in which the roots had grown to a length of 1 to 2 inches, but were much flattened, being closely appressed to the stem by the overlying leaf sheath. One case was found, however, where two such roots had become functional, producing numerous lateral roots. This case is illustrated in Fig. 16. Knife-cut, galls and internodal roots were found on D 1135 at Grove Farm only near the bases of cane shoots. Not a single example of any of these abnormalities was found to occur as much as a foot above the surface of the soil.

Galls on Canes in Other Countries

In our former paper, we noted that galls of the type now appearing on our canes here in Hawaii, were recorded as occurring on canes in Java as long ago as 1900. From the literature emanating from Java and from conversations with Miss Wilbrink we learn that gall production has never become sufficiently common in their cane cultures to arouse anything more than a curious interest. Their canes have never displayed such aggravated cases as are now frequently met with in several of our cane varieties.

Dr. Mangelsdorf recently called our attention to a paragraph in a paper by C. A. Barber* setting forth the results of his studies of sugar canes in India. Barber described proliferating stem galls such as we are now concerned with and also notes

* Barber, C. A. Studies in Indian Sugarcanes, No. 4. Memoirs of the Department of Agriculture in India, Botanical Series 10:56-57, 1919.

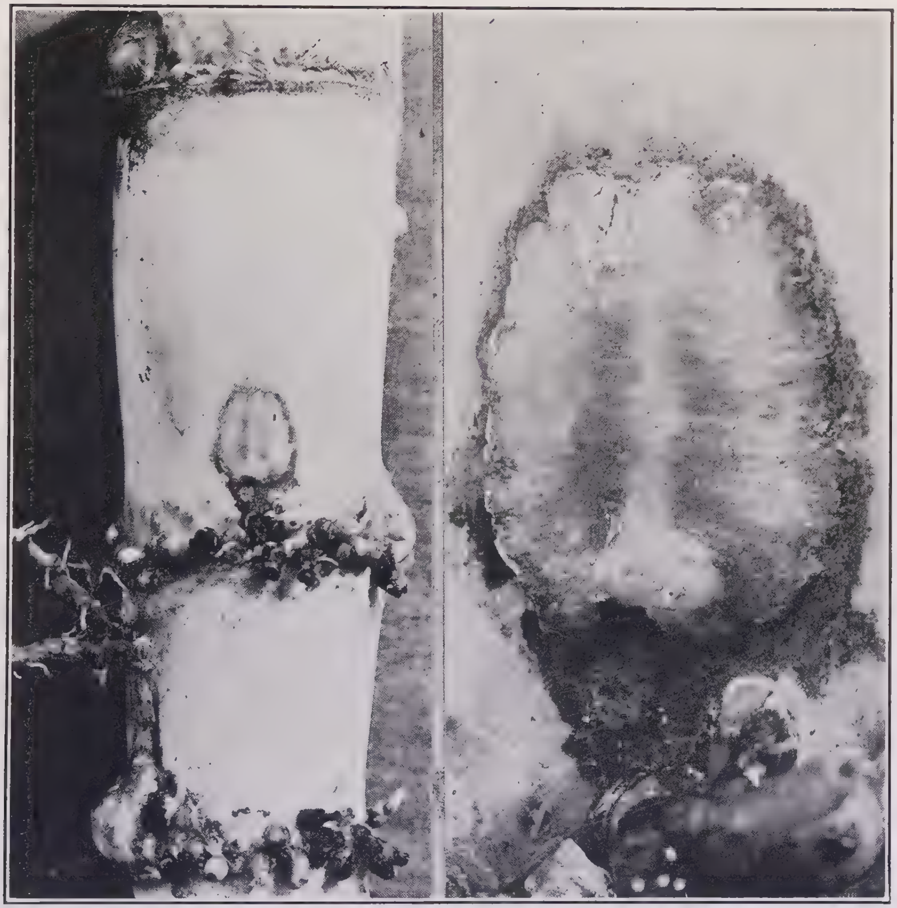


Fig. 16. At the left is shown a portion of a stick of D 1135 bearing functional internodal roots and a large shield-shaped gall. At the right the same gall is shown enlarged 6.9 diameters. Photos by Twigg Smith.

the simultaneous occurrence of knife-cuts, inferring that gall production may in some cases result from the "cuts." He illustrates his paper with drawings and photographs which leave no doubt but that he is dealing with abnormalities of exactly the same character as those now prevalent in our canes.

We quote Barber as follows:

"But the most striking and frequent case of abnormal bud formations is when they are irregularly produced in different parts of the stem without any regard to the usual position. They are often met with in the root zone, for here there is, more or less permanently, meristematic tissue, but they may also appear at almost any part of the joint. They may arise direct from the outer layers of the stem, but more usually they are preceded by the formation of an irregular mass of callus, over which the buds are distributed unevenly, varying from mere pin points of tissue to fully formed buds with scaly leaves. Curious monstrous forms are thus produced. . . . They would appear to be commoner on seedlings of certain parentage, although they have been found sporadically in almost all the plots, thus conveying the suggestion that the formation of cane plants from seed is no longer governed by the strict rules applicable to seed-bearing plants. In 1917-18 the *Khelia* plot of seedlings was thus marked out as containing numerous examples of this deformity. The cases thus far mentioned do not seem to have their origin in any injury to the cane tissues, but, in other cases, the callus results from the hole of a stem borer, the breaking of a cane, or the curious "cuts" above the bud in the groove, to which attention was drawn in the *Journal of Heredity* of February, 1916. These cuts have been found in many of our seedlings and cane varieties on the farm, and appear not to be the result of any insect or other attack, but on differences in tension of the superficial layers of the stem. They have been found also in seedlings of *Saccharum spontaneum* in some quantity, and various cases have been drawn at intervals during the past five years.

We sent a copy of the October *Record* to Mr. D. S. North in Australia and asked him to read our article on galls and then tell us what he knew about the occurrence of similar galls on canes in Australia and Fiji. His reply is so very interesting that we shall quote it at length:

In reply to your enquiry, I may state that I have seen many examples of external galls on sugar cane stalks, such as you describe. But I have not seen any such extreme cases as are illustrated in your figures 1, 2, 3, and 9, and Kamerling's Fig. 1.

I first noted these galls in 1907, on many stalks of Badila at Lautoka, Fiji. This was at the very commencement of my work on cane diseases (Fiji disease), before even the Fiji disease leaf galls had been noted. At that time I followed them up only until it became apparent that they had no specific connection with Fiji disease. Since then I have casually noted them frequently on stalks of Badila, and in rare cases on other varieties, in Fiji, Queensland, and N. S. W. These galls all corresponded exactly to your description on p. 493, under heading "Nature and Distribution of Galls," except that I have not observed aggravated cases accompanied by distortion, nor galls elaborating leaf tissue. However, adventitious bud production apparently from galls has been noted in a few isolated cases.

We have also had many examples of multiple bud production by newly raised seedling canes, notably by 7R428 (Pompey), in which this habit was particularly marked at first, and still persists to a slight extent after 20 years cultivation (in the tropics but not at N. S. W. mills). In this case, secondary (? adventitious) buds spring from the nodes close to and on either side of the primary bud in regular sequence. Nodes bearing a row of 11 and even 13 buds, circling half way round the stalk, have been frequently noted with Pompey in extreme cases. But this phenomenon seems quite independent of that of the galls now under consideration.

"Bunch-tops" are also of common occurrence with us. A photograph of one taken at Rarawai about 1914 is enclosed. (Reproduced herewith as our Fig. 17.) They occur more commonly at the subtropical (N. S. W.) mills than in the tropics. They were exceptionally

Fig. 17. A bunch-top which was found at Rarawai, Fiji. Photo supplied by Mr. D. S. North.

numerous all over this district last spring. Hundreds of them developed in a small ratoon variety experimental plot of about ¾ acre here at the mill, right under our eyes. The manner in which these bunch-tops are associated with arrowing, to my mind, lends strong support to the hypothesis of aborted arrows. In fact, your earlier conclusion, that "Bunch-top is a malgrowth resulting through the abortion of an inflorescence or tassel. The growing point of the shoot reverts to vegetative growth after starting the development of an inflorescence, and a bunch-top is the result," seems to fit the case exactly. They develop towards the end of the arrowing season, most freely in those varieties which are prone to arrow, commonly in stalks which have pointed up as if to arrow, and so forth. Specimens have been observed which apparently represent reversion to vegetative growth after the inflorescence has reached various stages in its development. Further, no galls are usually found in association with these bunch-tops. Altogether, I feel convinced that this must be the true explanation of most of the bunch-tops which I have seen.

Another kind of bunch-top, closely resembling your Fig. 4, also occurs here, associated with and apparently due to Curly Top disease, in Malabar and the other Tanna varieties. The symptoms characteristic of Knife-cut disease are also frequently associated with Curly Top, as also are symptoms closely resembling those shown in your Fig. 7 (both stalks), and those you describe on p. 498, 4th paragraph. This suggests some relationship between your gall disease and our Curly Top and Knife-cut diseases. The bifid and trifid sticks thus produced are apparently quite distinct from true dichotomous branching, of which I have seen some perfect examples, the canes being quite free from galls, distortion, abnormal leaf scars or other irregularities, which could connect them with bunch-tops.

In view of these observations, I consider that your conclusion that "we must . . . place bunch-top in the category of a gall induced by extraneous forces," may prove inapplicable to all cases. Rather, I think that two, three or more different types of bunch-tops may have to be recognized, especially as your conclusion seems so well founded in the case of the bunch-tops you studied.

In a personal letter to E. L. Caum, W. W. G. Moir states that he observed stem galls on certain of the Java seedlings now growing on the grounds of the Cuba Experiment Station at Santiago de las Vegas.

The Causal Factor Unknown

The factor which is causing the production of galls by our canes still remains undetected. While the evidence obtained from field observations strongly supports conclusions that the disease is infectious and spreads from cane to cane, we have not yet proven these conclusions by actual experiments. Many experiments have already been installed to gain information along these lines, but sufficient time has not yet elapsed to yield results.

We are not yet able to estimate the potential danger to the sugar industry which this disease represents. It may be very considerable, and then again it may be quite negligible. A number of the newer seedling canes, such as U. D. 47, 25-Q-88, 25-Q-137 and 26-Q-2673, have been quickly rendered absolutely worthless by the malady and a great many more have had their sticks so disfigured by galls as to make them at least unattractive. It is true that the majority of the canes attacked carry the disease, for a time at least, with little or no apparent loss in vigor or diminution in the size of sticks produced. Galled sticks must, however, expend energy and material in building gall tissue that might otherwise be reserved as sugar. There can be no doubt but that the ratio of juice to fibre is reduced in proportion to the volume of gall tissue elaborated.

It would look as though the majority of our standard big-stick canes are very resistant to the gall disease, and so long as they predominate in our cultures the disease will probably not be of any great economic importance. In many of the seedling canes secured through the crossing of Uba with other varieties, susceptibility to this disease appears to be greatly accentuated. By growing these canes we are cultivating the disease, greatly increasing the volume and distribution of infected and infectious material and possibly educating the causal factor up to a point where it may become more virulent than formerly among our big-stick canes.

A conspicuous feature noted and commented upon by all observers of these cane galls is that they reach their greatest development on the most vigorous and robust sticks of cane: the most succulent sticks exhibit the most aggravated examples of galls. This, however, is to be expected for the influence causing gall production is effective only on the tissues while they are in an embryonic or growing condition. The more rapidly a cane grows the more tissue will be in the embryonic condition at any one time and consequently the better the opportunity to elaborate numerous large galls.

In considering the possible danger to our industry represented by the gall disease we should remember that the mosaic disease presented a very similar problem when it was first recognized in our fields. Some canes were quite evidently seriously injured by it, while others contracted it and maintained such vigor that it took very careful experiments to determine the considerable loss which could not be detected by merely observing the canes in the field. In commenting upon the serious eye spot epidemics which have occurred on certain canes in Hawaii during recent years, Dr. F. A. F. C. Went writes: "The occurrence of eye spot disease is interesting because it shows that we should never underestimate an apparently harmless disease. Eye spot disease has occurred in Java from times unknown without causing any damage to speak of."

Notes on Yields and Stem Gall Occurrence of Some Uba Quarter-Breeds at Makiki

By J. A. Verret

These data are from a first harvest of a number of seedlings grown in 1925. They were planted in ten-foot sections with three checks each of H 109, D 1135 and Yellow Caledonia, and one section of Striped U. D. 1.

The cane was planted in March, 1926, and harvested in May, 1927. In planting, three-eye seed pieces with the two end eyes taken out were used. These were spaced one foot between eyes. Extra seed pieces were put in to replant any misses. In this way all the varieties had a uniform stand to begin with.

Previous to harvest and after being cut these canes were carefully inspected for stem galls. Galls were found on eighteen of the forty-two varieties in the plot.

No galls were found on H 109, D 1135, Yellow Caledonia or on Striped U. D. 1, being confined to the quarter-breed Ubas. In no case were these galls of an aggravated nature. They were very small and very few.

The varieties are listed in the order of their yields in the following table. The presence or absence of galls is also indicated:

25 Q SEEDLINGS IN ORDER OF SUGAR YIELD

Variety	Pounds Total Sugar per 10 Feet of Line	Remarks
25 Q 229	39.1	
25 Q 158	29.5	Stem galls
25 Q 214	29.4	Stem galls
25 Q 159	29.2	Stem galls
25 Q 156	28.8	Stem galls
25 Q 224	26.1	
25 Q 110	25.9	Stem galls
25 Q 177	25.6	
H 109	24.9	2 plots—27.4 and 22.4
25 Q 188	24.0	Stem galls
D 1135	23.5	3 plots—24.2, 24.2, 22.0
25 Q 25	22.8	
Yellow Caledonia	22.1	2 plots—24.4, 19.8
25 Q 124	21.5	Stem galls
U. D. 1 (Striped)	20.4	
25 Q 11	20.4	Stem galls
25 Q 167	20.1	Stem galls
25 Q 15	19.1	Stem galls
25 Q 18	19.0	Stem galls
25 Q 79	18.2	
25 Q 75	18.1	Stem galls
25 Q 184	18.0	
25 Q 113	16.7	
25 Q 4	15.9	
25 Q 1	15.1	Stem galls
25 Q 195	15.1	
25 Q 36	14.0	
25 Q 61	13.5	
25 Q 34	13.4	
25 Q 194	12.9	
25 Q 27	12.5	Stem galls
25 Q 7	12.1	Stem galls
25 Q 209	12.1	
25 Q 119	11.4	Stem galls
25 Q 162	11.2	Stem galls
25 Q 196	11.2	
25 Q 40	11.0	
25 Q 166	9.7	
25 Q 126	7.9	
25 Q 160	5.4	
25 Q 73	2.9	
25 Q 70	2.2	Stem galls

1925 UBA QUARTER BREEDS. CANES 14 MONTHS OLD AT HARVEST IN MAY 1927.
Each section 10 feet long and 5 feet wide. In planting eyes were spaced one foot apart. Varieties with gall are indicated. Those not marked were gall free.

H109 Used for seed	25Q1 Gall 57 T.C. 6.6 T.S.	25Q4 57 T.C. 6.9 T.S.	D1135 106 T.C. 10.5 T.S.	25Q7 Gall 50 T.C. 5.3 T.S.	25Q11 Gall 105 T.C. 8.9 T.S.
25Q15 Gall 81 T.C. 8.3 T.S.	25Q18 Gall 66 T.C. 8.3 T.S.	25Q25 99 T.C. 9.9 T.S.	25Q27 Gall 68 T.C. 5.4 T.S.	25Q34 70 T.C. 5.8 T.S.	25Q36 75 T.C. 6.1 T.S.
25Q40 41 T.C. 4.8 T.S.	25Q61 64 T.C. 5.9 T.S.	Striped U-D 1 77 T.C. 8.9 T.S.	25Q70 Gall 25 T.C. 1.0 T.S.	25Q73 25 T.C. 1.3 T.S.	Yellow Caledonia 84 T.C 10.6 T.S.
Yellow Caledonia 80 T.C. 8.6 T.S.	25Q75 Gall 76 T.C. 7.9 T.S.	25Q79 92 T.C. 7.9 T.S.	25Q110 Gall 114 T.C 11.8 T.S.	25Q113 66 T.C. 7.3 T.S.	25Q119 Gall 52 T.C 5.0 T.S.
25Q124 Gall 87 T.C. 9.4 T.S.	25Q126 56 T.C. 3.4 T.S.	25Q156 Gall 132 T.C. 12.5 T.S.	25Q158 Gall 111 T.C. 12.9 T.S.	H109 91 T.C. 9.8 T.S.	25Q159 Gall 117 T.C. 12.7 T.S.
25Q160 41 T.C. 2.4 T.S.	25Q162 Gall 49 T.C. 4.9 T.S.	D1135 86 T.C 9.6 T.S.	25Q166 68 T.C. 4.2 T.S.	25Q167 Gall 64 T.C. 8.8 T.S.	25Q177 84 T.C 11.2 T.S
H109 98 T.C 11.9 T.S.	25Q184 62 T.C 7.8 T.S.	25Q188 Gall 88 T.C 10.5 T.S	25Q194 63 T.C 5.6 T.S.	25Q195 67 T.C 6.6 T.S.	25Q196 49 T.C 49 T.S
25Q209 106 T.C 5.3 T.S.	25Q214 Gall 108 T.C. 12.8 T.S	Yellow Caledonia Used for Seed	25Q224 114 T.C 11.4 T.S	25Q229 118 T.C 17.0 T.S.	D1135 106 T.C 10.5 T.S

As seen in the above table, as well as on the chart shown here, several of these canes gave yields which indicate them to be worthy of further trial on a more extensive scale. On account of lack of repetitions and the small areas involved these figures are tentative only. But we feel that they give strong indications of the relative ranking of these canes. The conditions under which these canes were grown were very uniform as will be noted from the yields of the various check plots of standard canes listed in the chart before mentioned. This adds to the value of the results.

Seed from the best of these seedlings was taken for further planting. Seed from varieties showing stem gall was planted at the Mid-Pacific plots, while gall-free seed was taken to Kailua.

Reference to the table will show that stem galls were much more prevalent in the better yielding varieties than in the poorer ones. Of the five seedlings giving the best yields four were found with stem galls. We find 67 per cent of the total gall infection in the nineteen which head the list, with only 33 per cent in the poorer half of the lot. Of the nineteen better yielding varieties twelve were found with galls, while only six were found infected in the poorer nineteen. This same condition has been observed before within a variety itself. Generally it is the most vigorous stools and the fastest growing stalks which show the most galls.

The first and natural conclusion one arrives at from this condition of affairs is that vigorous canes are more susceptible to gall attack and that the presence of galls in most cases has very little, if any, depressing effect on the yields. But another remote possibility presents itself to which we feel attention should be called. Galls are formed by abnormal cells. These abnormal cells are the result of some unnatural stimulation in the plant produced by some unknown cause.

Now, it might be possible that the stimulation which causes the formation of these abnormal cells may also stimulate the formation of normal ones and thereby cause some increase growth in cases when the gall attack is not too severe.

We do not intend this to mean that we should disregard galls. We feel that until we know more about them we should all be very careful how we spread the more susceptible varieties.

The Effect of Fertilizer Constituents on Eye Spot at the Waialua Agricultural Company, Ltd.

The following experiment was undertaken to determine conclusively the relation of fertilizer programs to eye spot occurrence, not only of the nitrogen constituents, but also of potash and phosphoric acid.

In Field Valley 1B at the Waialua Agricultural Company, growing H 109 planted June, 1926, a checkerboard test was laid out in which 10 plots were treated with high amounts of nitrogen, 10 plots with no nitrogen, 10 plots with high potash, 10 plots with no potash, 10 plots with high phosphoric acid, 10 plots with no phosphoric acid, and 10 plots with usual plantation fertilizer practice. These fertilizers were applied on August 26, 1926. The amounts of each of the different fertilizer constituents used are shown in the upper left-hand part of Fig. 1.

The amounts of eye spot infection in each plot were measured by means of infection counts of 200 leaves per treatment. These were secured by selecting 20 stalks well distributed in each plot, and marking each stalk with a red cloth for subsequent identification. On each stalk the third leaf from the youngest was selected and the eye spot infections counted; since there was one leaf on each stalk, and 20 stalks per plot, this made 20 leaves counted per plot, and with 10 replications of each fertilizer treatment, there were infection counts on 200 leaves for each treatment. The total infections on these leaves were then averaged per leaf. Such infection counts were made at two-week intervals beginning on August 30.

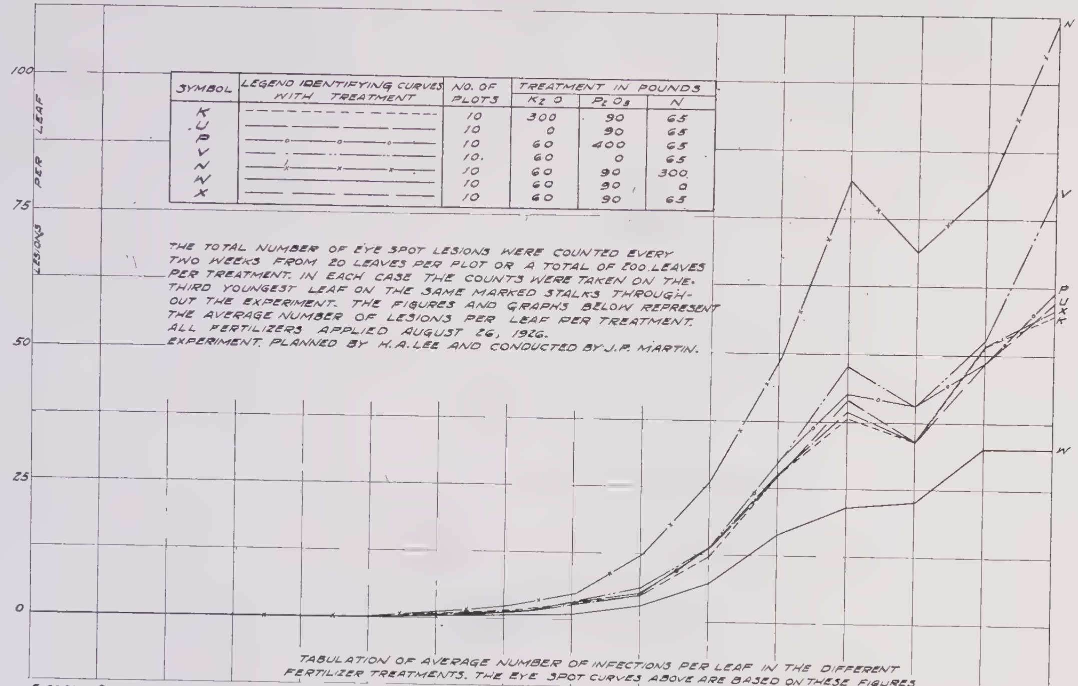
The average infections per leaf for each treatment are charted in Fig. 1.

Examining this figure, one sees that infections averaged less than 1 per leaf until November 22. Infections then began to increase and reached the first peak on February 14; favorable weather then brought about a recession in eye spot for two weeks, but severe eye spot weather then set in causing a second much more severe infection on March 28.

From November 22 onward eye spot was consistently most severe in the plots treated with high nitrogen; the plots receiving no nitrogen were consistently less affected than the other plots. Plots with no nitrogen averaged but 32.8 infections per leaf at the highest peak of infection, which would cause but negligible injury to the cane plant. Plots with 65 pounds of nitrogen per acre averaged 58 infections per leaf or 77 per cent more than the plots with no nitrogen. Plots with

FIG. 1:— THE EFFECT UPON EYE SPOT OF APPLICATIONS OF THE VARIOUS FERTILIZER CONSTITUENTS TO THE CANE

LOCATION:- WAIALUA AGRICULTURAL CO., LTD. FIELD VALLEY 1 B
DATE :- AUGUST 30, 1926 TO MARCH 28, 1927.



SYMBOL	NO. OF PLOTS	TREATMENT IN POUNDS K_2O	P_2O_5	N
K	10	300	90	65
U	10	0	90	65
P	10	60	400	65
V	10	60	0	65
N	10	60	90	300
W	10	60	90	0
X	10	60	90	65

TABULATION OF AVERAGE NUMBER OF INFECTIONS PER LEAF IN THE DIFFERENT FERTILIZER TREATMENTS. THE EYE SPOT CURVES ABOVE ARE BASED ON THESE FIGURES.

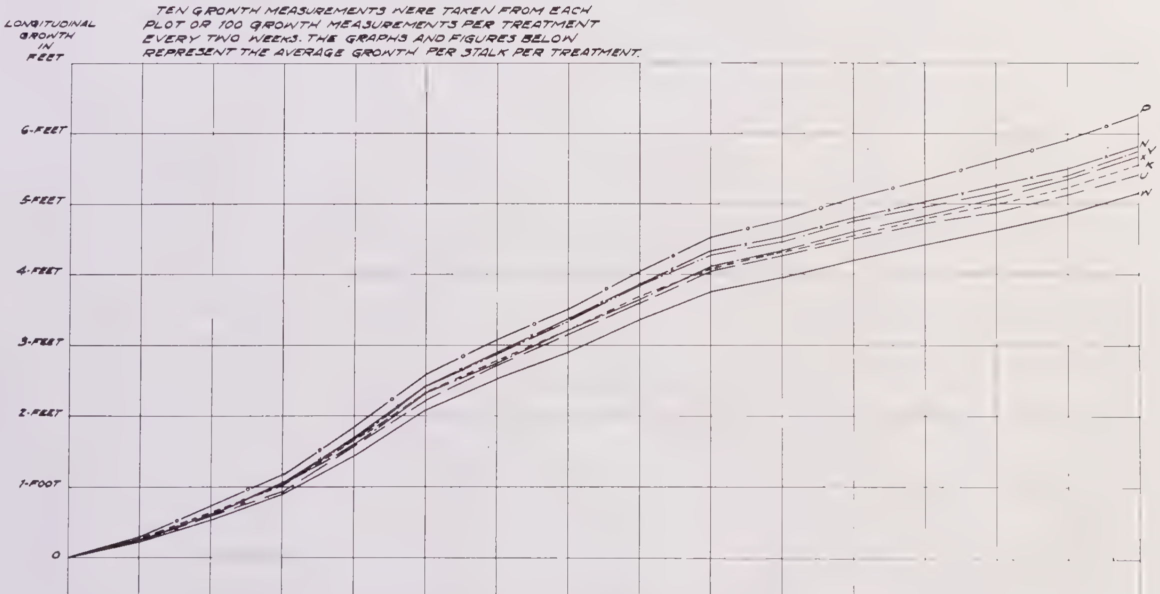
8-30-26	9-13-26	9-27-26	10-11-26	10-26-26	11-8-26	11-22-26	12-6-26
	2-WKS.	4-WKS.	6-WKS.	8-WKS	10-WKS	12-WKS.	14-WKS.
	P=0.11	N=0.19	V=0.21	U=0.32	N=0.50	N=1.35	N=2.48
	K=0.09	P=0.12	P=0.15	X=0.32	K=0.34	K=0.87	K=1.68
	N=0.08	U=0.11	U=0.14	N=0.31	V=0.34	U=0.86	V=1.47
	W=0.07	W=0.10	K=0.14	W=0.30	X=0.33	V=0.81	P=1.33
	U=0.05	X=0.10	W=0.13	K=0.30	U=0.32	X=0.77	X=1.33
	X=0.05	V=0.09	N=0.12	V=0.30	P=0.32	P=0.70	U=1.23
	V=0.04	K=0.06	X=0.10	P=0.28	W=0.29	W=0.36	W=0.72

12-20-26	1-3-27	1-17-27	1-31-27	2-14-27	2-28-27	3-14-27	3-28-27
16-WKS.	18-WKS	20-WKS.	22-WKS.	24-WKS.	26-WKS.	28-WKS.	30-WKS.
N=4.77	N=12.04	N=25.61	N=48.45	N=83.94	N=68.94	N=80.57	N=110.94
P=3.15	U=6.48	V=13.96	P=30.28	V=47.98	P=40.64	V=51.97	V=79.15
U=2.97	V=6.36	P=13.96	V=29.77	P=42.52	V=40.22	K=51.82	P=61.48
V=2.96	X=5.34	X=13.88	X=27.44	U=41.44	U=34.10	X=51.70	U=59.92
X=2.91	K=4.90	U=13.15	K=27.18	X=39.02	K=34.00	P=48.43	X=58.21
K=2.65	P=4.76	K=11.56	U=26.90	K=37.94	X=33.67	U=48.25	K=57.26
W=1.20	W=2.85	W=7.07	W=16.28	W=21.48	W=22.51	W=32.83	W=32.69

Fig. 1

FIG. 2:— GROWTH MEASUREMENTS FROM THE FERTILIZER TREATMENTS SHOWN IN FIGURE 1

THE CURVES IDENTIFYING THE TREATMENTS ARE THE SAME AS IN FIGURE 1



TABULATION OF AVERAGE LONGITUDINAL FEET OF GROWTH PER STALK OF CANE IN THE VARIOUS SERIES OF PLOTS RECEIVING DIFFERENT FERTILIZER TREATMENTS. THE GROWTH CURVES ABOVE ARE BASED ON THESE FIGURES.

8-30-26	9-13-26	9-27-26	10-11-26	10-25-26	11-8-26	11-22-26	12-6-26
	2-WKS.	4-WKS.	6-WKS.	8-WKS.	10-WKS.	12-WKS.	14-WKS.
	P=0.29	P=0.74	P=1.15	P=1.82	P=2.58	P=3.05	P=3.49
	K=0.27	K=0.62	N=1.02	N=1.67	N=2.40	N=2.87	N=3.34
	U=0.26	N=0.62	X=1.01	V=1.63	V=2.40	V=2.86	V=3.32
	N=0.26	V=0.61	K=1.00	K=1.60	X=2.31	K=2.76	X=3.19
	V=0.26	X=0.60	V=0.97	X=1.57	K=2.30	X=2.75	K=3.18
	X=0.24	U=0.59	U=0.92	U=1.53	U=2.20	U=2.70	U=3.12
	W=0.22	W=0.53	W=0.89	W=1.42	W=2.07	W=2.51	N=2.89

12-20-26	1-3-27	1-17-27	1-31-27	2-14-27	2-28-27	3-14-27	3-28-27
16-WKS.	18-WKS.	20-WKS.	22-WKS.	24-WKS.	26-WKS.	28-WKS.	30-WKS.
P=4.01	P=4.52	P=4.75	P=5.08	P=5.34	P=5.63	P=5.90	P=6.25
N=3.83	N=4.31	N=4.52	N=4.80	N=5.02	N=5.26	N=5.50	N=5.80
V=3.82	V=4.26	V=4.46	V=4.75	V=4.96	V=5.18	V=5.39	V=5.72
K=3.67	X=4.11	X=4.39	X=4.60	X=4.84	X=5.08	X=5.33	X=5.65
X=3.64	K=4.07	K=4.30	K=4.55	K=4.79	K=4.99	K=5.22	K=5.52
U=3.58	U=4.03	U=4.25	U=4.50	U=4.72	U=4.89	U=5.11	U=5.39
W=3.34	W=3.75	W=3.96	W=4.20	W=4.42	W=4.63	W=4.85	W=5.14

Fig. 2

300 pounds of nitrogen per acre averaged 111 infections per leaf or 238 per cent more infections than the plots with no nitrogen.

It seems established therefore that nitrogen applications in the fall months increase eye spot infection.

Turning to the phosphoric acid applications; in this field, plots with no phosphoric acid had more infection consistently throughout the experiment than the plots with 400 pounds of phosphoric acid per acre, and at the first peak of infection there was 12 per cent more infection in the plots with no phosphoric acid. At the second peak of infection there was 28 per cent more infection in the no phosphoric acid plots than in the high phosphoric acid plots. From the results of this experiment alone it would be difficult to say that these results were significant and that phosphoric acid applications reduced eye spot, since the differences were not large and might be due to chance. However, it is well to keep these results with phosphoric acid in mind.

At both high peaks of infection, plots with 300 pounds of potash per acre had slightly less infection per leaf than plots with no potash per acre, but the differences in this case are also so slight that one cannot be sure but that these differences are merely due to chance. Nevertheless these results should also be kept in mind.

Turning to the growth curves shown in Fig. 2, one is surprised to observe that in this field phosphoric acid gave a better growth response to the cane than the nitrogen. The plots treated with 400 pounds of phosphoric acid per acre averaged 7.2 inches more longitudinal growth per stalk than the plots with usual plantation practice (90 lbs. P_2O_5 p. a.), a very profitable increased yield in seven months from time of application. The plots with 300 pounds of nitrogen per acre averaged 1.8 inches more longitudinal growth per stalk in seven months, than the usual plantation practice (65 lbs. N per acre at this application). Potash applications did not increase growth in this field.

Summary

With ten replications of plots for each treatment the following conclusions seem warranted:

(1) Phosphoric acid applications materially increased the longitudinal growth of the cane in this experiment, considerably more so than nitrogen applications.

(2) However, increased growth from phosphoric acid did not result in increased eye spot. The reverse occurred; plots treated with 400 pounds of phosphoric acid showed smaller eye spot counts at the peaks of infection than plots with no phosphoric acid. The differences in infection, however, do not seem to be large enough to be significant at least from these results alone, but should be kept in mind in connection with subsequent experiments.

(3) The plots with 300 pounds of potash per acre showed less eye spot than the plots with no potash quite consistently throughout the experiment and more pronounced at the two peaks of infection. However, the differences in infection are not sufficiently great to be significant, at least from the results of this experiment alone. Nevertheless these results should also be kept in mind.

(4) Applications of inorganic nitrogen fertilizers to H 109 cane in the late summer and fall months, in fields with topography and climatic conditions favorable to eye spot, greatly increased the severity of the disease.

(5) The conclusion is evident that applications of fertilizers containing inorganic nitrogen should not be applied in the late summer or fall months, to fields of H 109 with a history of eye spot or where, from the topography of the field eye spot would be expected to be severe.

Experiment laid out and conducted by J. P. Martin, with the cooperation of the Waialua Agricultural Company, Ltd.

Experiment planned by H. Atherton Lee.

H. A. L.

The Effect of Fertilizer Constituents on Eye Spot at the Kilauea Sugar Plantation Company

In Field 36 at the Kilauea Sugar Plantation Company the effect of the various fertilizer constituent tests upon eye spot was tested out in a checkerboard field test. The eye spot intensity was compared between series of plots of cane treated with very high applications of nitrogen fertilizers, plots with more moderate applications of nitrogen, plots with high applications of phosphoric acid, plots with moderate applications of phosphoric acid, plots with high applications of potash, plots with moderate applications of potash, and plots of usual plantation practice. The fertilizers of usual plantation practice were applied in July, 1926, and the fertilizers with the high rates of applications of the various constituents were applied in September, 1926. In each series of fertilizer treatments there were six replications of plots. The layout of the experiment is shown to the left in Fig. 1.

The cane in this field consisted of H 109, second ratoons, previously harvested in July, 1926. The plots consisted, each of 6 rows of cane, running from level ditch to level ditch as shown in Fig. 1.

The amounts of the fertilizer constituents applied in September were excessively high, for the purpose of accentuating any differences which might occur in the severity of eye spot infection resulting from the various treatments. The amounts of such constituents are also shown in the table in Fig. 1.

The severity of eye spot infection was measured in the different plots, from eye spot counts, made as described in previous experiments; in the case of this test such eye spot counts were made from the 2 youngest leaves per stalk, from 20 stalks per plot. Since there were 6 replications of plots for each treatment there were thus 240 leaf counts of infections for each treatment. Such eye spot counts were made every two weeks.

The average infections per leaf in each series of plots of the different fertilizer treatments are charted in Fig. 1.

Disregarding the effect of the different fertilizer treatments on the disease, for the time being, it can be seen from Fig. 1, that in Field 36, infections averaged less than 3 per leaf up to November 19, 1926. Infections per leaf then multiplied

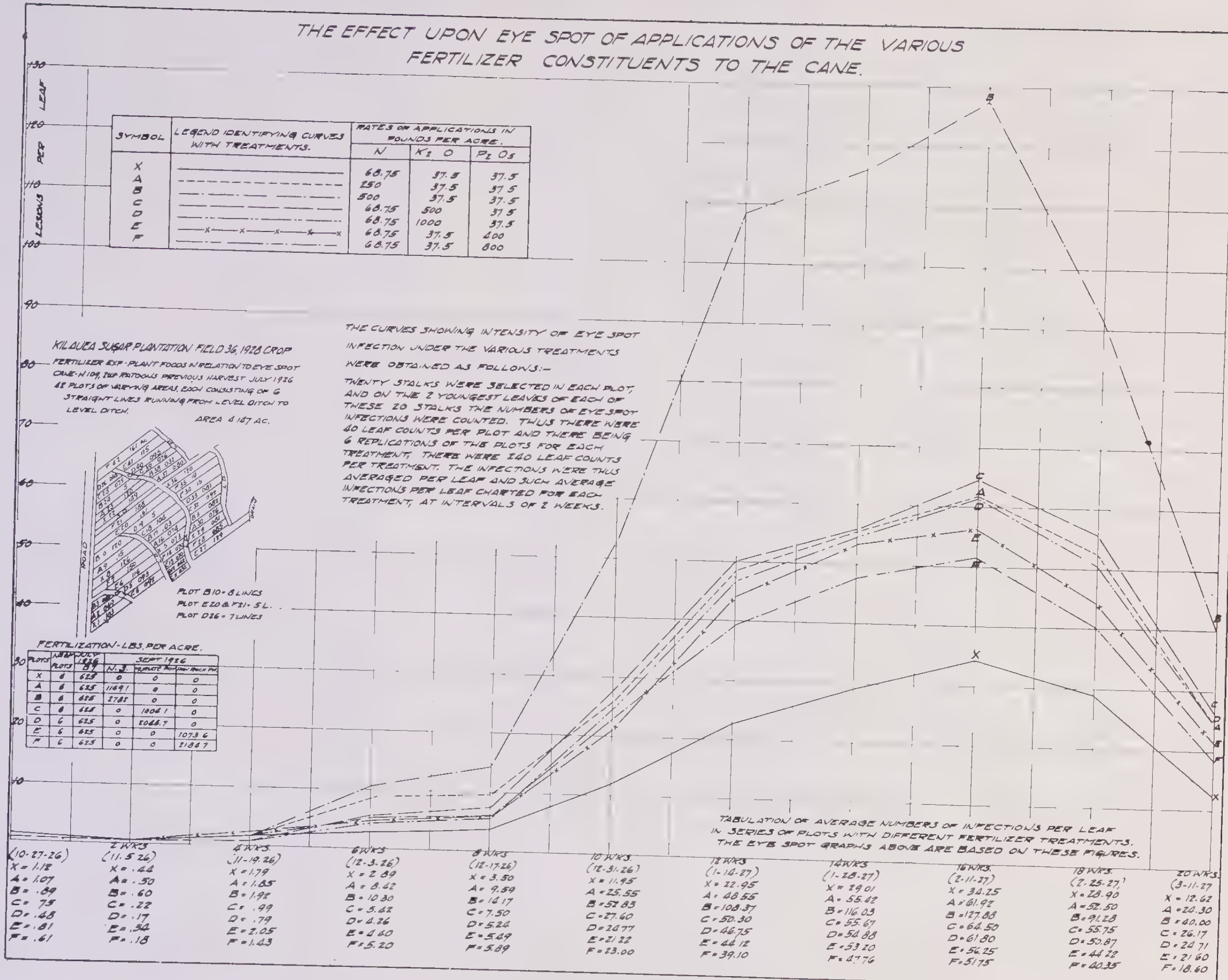

THE EFFECT UPON EYE SPOT OF APPLICATIONS OF THE VARIOUS FERTILIZER CONSTITUENTS TO THE CANE.
LESIONS PER LEAF
SYMBOL
LEGEND IDENTIFYING CURVES WITH TREATMENTS.
RATES OF APPLICATIONS IN POUNDS PER ACRE.
N
K2 O
P2 O5
X 68.75 37.5 37.5
A 250 37.5 37.5
B 500 37.5 37.5
C 68.75 500 37.5
D 68.75 1000 37.5
E 68.75 37.5 400
F 68.75 37.5 800
KILAUEA SUGAR PLANTATION FIELD 36, 1928 CROP
FERTILIZER EXP.-PLANT FOODS IN RELATION TO EYE SPOT
CANE-H 109, 2ND RATOONS PREVIOUS HARVEST JULY 1926
42 PLOTS OF VARYING AREAS, EACH CONSISTING OF 6 STRAIGHT LINES RUNNING FROM LEVEL DITCH TO LEVEL DITCH.
AREA 4.187 AC.
ROAD
PLOT B10 - 8 LINES
PLOT E20 & F21 - 5 L.
PLOT D26 - 7 LINES
FERTILIZATION - LBS. PER ACRE.
THE CURVES SHOWING INTENSITY OF EYE SPOT INFECTION UNDER THE VARIOUS TREATMENTS WERE OBTAINED AS FOLLOWS:-
TWENTY STALKS WERE SELECTED IN EACH PLOT, AND ON THE 2 YOUNGEST LEAVES OF EACH OF THESE 20 STALKS THE NUMBERS OF EYE SPOT INFECTIONS WERE COUNTED. THUS THERE WERE 40 LEAF COUNTS PER PLOT AND THERE BEING 6 REPLICATIONS OF THE PLOTS FOR EACH TREATMENT, THERE WERE 240 LEAF COUNTS PER TREATMENT. THE INFECTIONS WERE THUS AVERAGED PER LEAF AND SUCH AVERAGE INFECTIONS PER LEAF CHARTED FOR EACH TREATMENT, AT INTERVALS OF 2 WEEKS.
TABULATION OF AVERAGE NUMBERS OF INFECTIONS PER LEAF IN SERIES OF PLOTS WITH DIFFERENT FERTILIZER TREATMENTS. THE EYE SPOT GRAPHS ABOVE ARE BASED ON THESE FIGURES.
(10-27-26) X = 1.12 A = 1.07 B = .69 C = .75 D = .48 E = .81 F = .61
2 WKS (11-5-26) X = .44 A = .50 B = .60 C = .22 D = .17 E = .34 F = .18
4 WKS (11-19-26) X = 1.79 A = 1.85 B = 1.92 C = .99 D = .79 E = 2.05 F = 1.43
6 WKS (12-3-26) X = 2.89 A = 8.42 B = 10.30 C = 5.42 D = 4.26 E = 4.60 F = 5.20
8 WKS (12-17-26) X = 3.50 A = 9.59 B = 14.17 C = 7.50 D = 5.24 E = 5.49 F = 5.89
10 WKS (12-31-26) X = 11.95 A = 25.55 B = 52.83 C = 27.60 D = 20.77 E = 21.22 F = 23.00
12 WKS (1-14-27) X = 22.95 A = 48.55 B = 108.37 C = 50.30 D = 46.75 E = 44.12 F = 39.10
14 WKS (1-28-27) X = 29.01 A = 55.42 B = 116.03 C = 55.67 D = 54.88 E = 53.20 F = 47.76
16 WKS (2-11-27) X = 34.25 A = 61.92 B = 127.88 C = 64.50 D = 61.80 E = 56.25 F = 51.75
18 WKS (2-25-27) X = 28.90 A = 52.50 B = 91.28 C = 55.75 D = 50.87 E = 44.22 F = 40.35
20 WKS (3-11-27) X = 12.62 A = 20.30 B = 40.00 C = 26.17 D = 24.71 E = 21.60 F = 18.60

Fig. 1

rapidly during December and January, reaching the peak of infection on February 11, in this field, and then decreasing rapidly during March. This peak of eye spot infection in the winter months is a usual thing, and is explained naturally by the shorter length of days in November, December and January with longer periods of dew on the leaves, and more moisture on the leaves from the more frequent winter rains.

Turning attention to the effect of the different fertilizer constituents on eye spot infection, it can be seen from the eye spot graphs in Fig. 1 that high applications of nitrogen fertilizers tremendously increased the severity of the disease. Yet if one observes the growth curves in Fig. 2, it can be observed that nitrogen produced no growth response in this field at Kilauea; the absence of a growth response from nitrogen applications is not an uncommon thing at Kilauea. Yet in spite of the absence of a growth response, inorganic nitrogen fertilizers increased eye spot severely.

Our previous conception of the effect of fertilizers, particularly nitrogen, in increasing eye spot, was that a more soft, succulent growth was produced which was susceptible.. These results at Kilauea showing no growth response from nitrogen applications, but an immense eye spot reaction, alter our previous conception of the role of nitrogen fertilizers in increasing eye spot. The decided growth response from phosphoric acid fertilizers in Field Valley 1B at Waialua, with no corresponding eye spot increase, while nitrogen fertilizers greatly increased infection without as great a growth increase in the cane, is in support of these results at Kilauea, indicating that the increase in eye spot following nitrogen fertilizer applications is not due to soft, more succulent cane. The logical conception at present is, that the inorganic nitrogen gets into the cane juices of the leaves and such juices then provide a better medium for the development of the eye spot fungus, than juices without inorganic nitrogen.

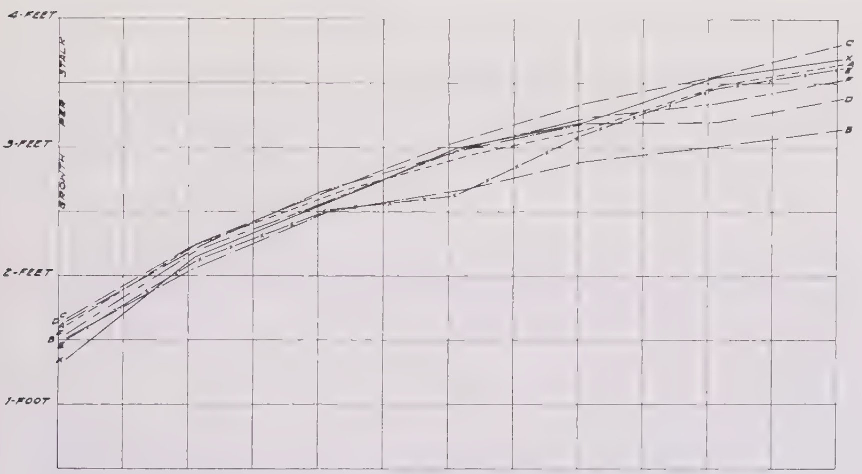
From an abstract viewpoint the results are of interest in an effort to increase resistance of H 109 to eye spot, by a study of the supply of nutrients.

From a plantation viewpoint, the results indicate clearly that applications of fertilizers containing nitrogen in H 109 fields of probable eye spot occurrence, should be avoided in the late summer and fall months, in order to escape the eye spot response during the winter months of short daylight, longer periods of dew, and greater probabilities of wet leaves from rainfall and kona weather. In theory, applications of nitrogen fertilizers should be made to such fields at such a time that the physiological response would occur in May, June or July, during the period of the greatest length of sunlight, less persistent dew on the leaves, and less chances for rainfall.

In Fig. 1, it can be seen that the eye spot response is greater from moderate applications of potash (Curve C) than from large amounts of potash (Curve D). This difference in favor of the large applications of potash was consistent through most of the period of the experiment. The decrease in eye spot was not great, and possibly is not significant, but at least merits passing note, for consideration in connection with subsequent experiments.

FIG. 2:— GROWTH MEASUREMENTS FROM THE FERTILIZER TREATMENTS SHOWN IN FIGURE 1
THE CURVES IDENTIFYING THE TREATMENTS ARE SAME AS IN FIGURE 1

GROWTH CURVES ARE BASED ON 10 GROWTH MEASUREMENTS PER PLOT AND WITH 6 REPLICATIONS OF THE PLOTS OF EACH TREATMENT THERE ARE THEREFORE 60 GROWTH MEASUREMENTS PER TREATMENT. THE LAYOUT OF THE EXPERIMENT IS SHOWN IN FIGURE 1.



TABULATION OF AVERAGE GROWTH IN FEET PER STALK OF CANE IN PLOTS WITH DIFFERENT FERTILIZER TREATMENTS. THE GROWTH CURVES ABOVE ARE BASED ON THESE FIGURES.

(10-22-26)	2 WKS. (11-5-26)	4 WKS. (11-19-26)	6 WKS. (12-3-26)	8 WKS. (12-17-26)	10 WKS. (12-31-26)	12 WKS. (1-14-26)
A = 1.61	A = 2.24	A = 2.62	A = 2.92	A = 3.14	A = 3.47	A = 3.66
B = 1.51	B = 2.07	B = 2.49	B = 2.66	B = 2.89	B = 3.00	B = 3.23
C = 1.66	C = 2.24	C = 2.65	C = 3.05	C = 3.33	C = 3.56	C = 3.81
D = 1.64	D = 2.22	D = 2.67	D = 2.96	D = 3.18	D = 3.19	D = 3.37
E = 1.50	E = 2.12	E = 2.50	E = 2.63	E = 3.11	E = 3.46	E = 3.62
F = 1.53	F = 2.19	F = 2.57	F = 2.92	F = 3.23	F = 3.33	F = 3.52
X = 1.34	X = 2.15	X = 2.56	X = 2.93	X = 3.18	X = 3.54	X = 3.69

Fig. 2

Also plots with large applications of phosphoric acid (Curve F) showed less eye spot than plots with more moderate applications of phosphoric acid (Curve E). The difference here is also slight and in itself is of questionable significance. In connection with similar results at Waialua it is also suggestive that phosphoric acid decreases eye spot slightly. It would be expected that the effect of phosphoric acid and potash fertilizers, if any, on eye spot would vary in different fields of different soil complexes. It can be concluded at least that applications of phosphoric acid and potash fertilizers may produce growth responses, without increasing eye spot infection.

The effect of the time of application of fertilizers on eye spot is shown to some extent by comparing the curve for plots treated with usual plantation practice (Curve X) in which, nitrogen, phosphoric acid and potash, all were applied in July, with curves A, B, C, D, E, and F in which applications of fertilizer constituents were made in September. The evidence in this case is very clear that early applications of fertilizers result in a considerable avoidance of eye spot infection.

Summary

(1) Nitrogen fertilizers in September at high rates of application in an H 109 field favorable to eye spot occurrence, greatly increased eye spot, although no growth response resulted to the cane.

(2) Plots treated with potash fertilizers at high rates of application showed slightly less eye spot than plots with more moderate rates of potash application.

(3) Plots treated with phosphoric acid fertilizers at high rates of application showed slightly less eye spot than plots with more moderate rates of phosphoric acid application.

(4) Plots receiving usual plantation fertilizer practice at Kilauea, in which all fertilizer constituents were applied in July, showed much less eye spot than the plots receiving fertilizer applications in September.

Experiment laid out and conducted by Royden Bryan with the cooperation of the Kilauea Sugar Plantation Company.

Experiment planned by H. Atherton Lee.

H. A. L.

The Effect of Potash Fertilizers on Eye Spot at the Waimanalo Sugar Company

This test was carried on in H 109 second ratoons in Field 14 at the Waimanalo Sugar Company. Eight plots, each plot of 10 rows, each row 30 feet long, were treated with sulphate of potash at the rate of 600 pounds per acre early in October, 1926. Eight alternating plots were left untreated as controls. All plots had previously received the usual plantation fertilizer practice of 185 pounds of nitrogen, 55 pounds of phosphoric acid, and 55 pounds of potash per acre, and with

the exception of the potash treatments all plots were treated identically as to cultivation, irrigation and fertilization.

The degree of eye spot infection in the different plots was measured by means of eye spot counts. In each plot, 20 stalks were selected and marked with a red cloth for future identification. Thereafter at two-week intervals the number of infections on the two youngest leaves of each of these stalks was counted. Since there were two leaves per stalk and 20 stalks per plot, there were counts made on 40 leaves per plot, and with 8 replications of the plots of each treatment there were thus 320 leaves counted for each treatment. The numbers of infections were then averaged per leaf from the counts made on these 320 leaves per treatment.

The average infections per leaf in the plots treated with potash, and in the untreated plots, are charted throughout the eye spot season in the illustration. It can be seen that infection at Waimanalo started to increase materially in both series of plots on February 3, 1927, and reached a first peak of infection, an average of 155 lesions per leaf, on March 3. Due to severe weather favoring eye spot, there was a second peak of infection, averaging 364 infections per leaf, on April 4, and then a rapid decrease in four weeks to less than 10 infections per leaf on May 9.

One of the outstanding features shown in this chart is the high degree of infection as late in the year as April. Another notable feature is the rapid decrease in eye spot in May, due entirely to natural causes such as steady northeast trade winds and greater periods of sunshine.

At the first peak of infection the plots with potash averaged 10 infections per leaf less than the plots without the potash treatment. At the second peak of infection, plots with potash averaged 17 infections per leaf less than the plots without the potash treatment. One is inclined to question whether this lessened infection is due to chance or actually is brought about by the applications of potash. An analysis of the data at the peaks of infection, as shown in Table 1, indicates that the results are fairly consistent in that the plots with potash treatment in a large proportion of plots had less average lesions per leaf than the untreated plots.

TABLE 1

Showing Average Infections per Leaf in Each Plot, During the Period of High Infection

	Average infections per leaf			
Plot No.	March 3	March 19	April 4	April 20
1 K	120	41	222	296
2 X	127	76	248	183
3 K	100	54	200	173
4 X	115	100	263	207
5 K	149	211	296	220
6 X	98	66	319	233
7 K	146	67	286	260
8 X	125	85	326	242
9 K	119	81	234	201
10 X	156	161	246	187
11 K	173	141	277	180
12 X	219	69	273	230
13 K	169	70	263	180
14 X	223	97	269	169
15 K	187	76	90	155
16 X	161	91	251	196

FIG. 1:— THE EFFECT OF POTASH AS A FERTILIZER AGAINST EYE SPOT AT THE WAIMANALO SUGAR CO.

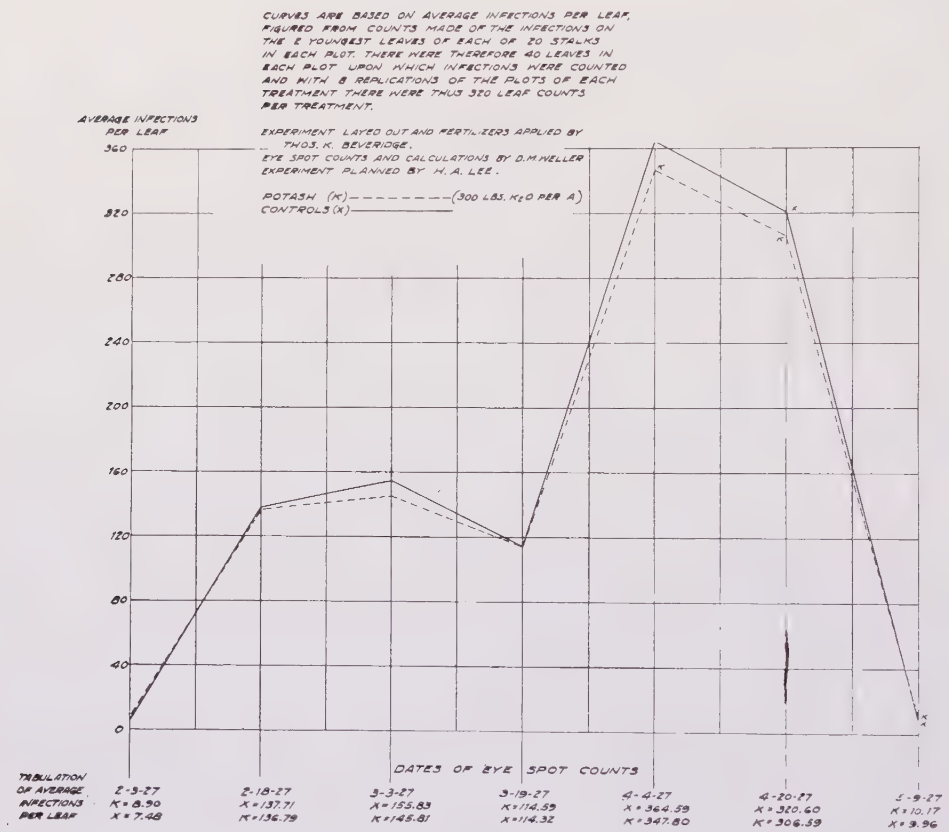


Fig. 1

Briefly, a preponderant proportion of the alternating plots treated with potash, shows less eye spot as shown in Table 1, than the plots without potash treatment.

These results in conjunction with the results at the Waialua Agricultural Company and the Kilauea Sugar Plantation Company, in which potash applications also reduced eye spot infection slightly, lead to the feeling that such potash applications do lessen eye spot definitely, at least in the fields in which the tests were carried on. The reduction in eye spot secured from such treatments was not large, but very often the difference of 10 or 15 infections per leaf is the difference between top rot and merely leaf infection; the former resulting in severe injury to the crop, and the latter resulting only in minor injury.

Summary

At the peaks of eye spot infection 8 plots of cane with applications of potash fertilizers to the soil averaged slightly less infection per leaf than untreated plots.

Experiment laid out by Thos. K. Beveridge.
Eye spot counts by D. M. Weller.
Experiment planned by H. Atherton Lee.

H. A. L.

The Effect Upon Eye Spot of Increased Time Intervals Between Irrigation Applications

In theory there seem to be three factors contributing to eye spot infection of H 109 cane which are affected by lessening irrigation water. The first is the lessened dew, which results from having a dry soil surface which is not evaporating moisture into the air to subsequently condense on the cane leaves. In other words, apparently much of our dew is formed from atmospheric humidity which has resulted from the evaporation of moisture from a wet soil surface. If the soil surface is not kept constantly wet by frequent irrigation applications, dew on the cane leaves is consequently reduced. The second factor influenced by decreased irrigation water is transpiration of the cane leaves; less irrigation means less transpiration by the cane leaves and consequently less dew on the leaves. The third effect, in theory at least, is on the plant itself, which when irrigation is withheld is not as soft and succulent and therefore not as susceptible as when irrigation is frequent.

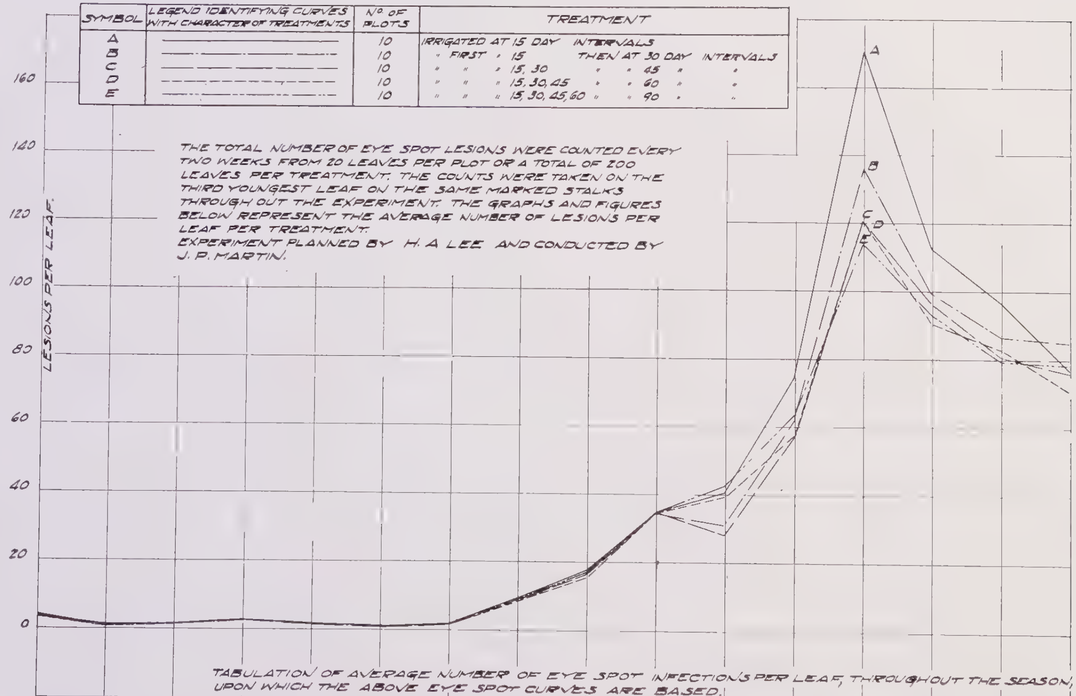
To determine the practical value of such lessened irrigation, and also its effect on the cane growth, an experiment was undertaken with five series of ten plots each, each series having different time intervals between the applications of irrigation. This test was undertaken in Field Gay 3 of the Waialua Agricultural Company, the ratoons of which were started in June, 1926. In the experiment

FIG. 1:— THE EFFECT UPON EYE SPOT DISEASE OF DECREASED IRRIGATION, RESULTING FROM INCREASED TIME INTERVALS BETWEEN IRRIGATION APPLICATIONS

LOCATION:- WAIALUA AGRICULTURAL CO. LTD., AUGUST 13, 1926 TO MARCH 11, 1927. FIELD GAY 3, H 109 CANE.

SYMBOL	LEGEND IDENTIFYING CURVES WITH CHARACTER OF TREATMENTS	Nº OF PLOTS	TREATMENT
A	————————	10	IRRIGATED AT 15 DAY INTERVALS
B	—·—·—·—	10	" FIRST " 15 THEN AT 30 DAY INTERVALS
C	— — — —	10	" " " 15, 30 " " 45 " "
D	- - - - - -	10	" " " 15, 30, 45 " " 60 " "
E	—··—··—	10	" " " 15, 30, 45, 60 " " 90 " "

THE TOTAL NUMBER OF EYE SPOT LESIONS WERE COUNTED EVERY TWO WEEKS FROM 20 LEAVES PER PLOT OR A TOTAL OF 200 LEAVES PER TREATMENT. THE COUNTS WERE TAKEN ON THE THIRD YOUNGEST LEAF ON THE SAME MARKED STALKS THROUGH OUT THE EXPERIMENT. THE GRAPHS AND FIGURES BELOW REPRESENT THE AVERAGE NUMBER OF LESIONS PER LEAF PER TREATMENT.
EXPERIMENT PLANNED BY H. A. LEE AND CONDUCTED BY J. P. MARTIN.



TABULATION OF AVERAGE NUMBER OF EYE SPOT INFECTIONS PER LEAF, THROUGHOUT THE SEASON, UPON WHICH THE ABOVE EYE SPOT CURVES ARE BASED.

8-13-26	8-27-26	9-10-26	9-24-26	10-8-26	10-22-26	11-5-26	11-19-26*	12-3-26
	2-WKS.	4-WKS.	6-WKS.	8-WKS.	10-WKS	12-WKS.	14-WKS.	16-WKS
C=4.39	A=1.17	E=1.89	E=2.40	D=1.65	E=1.10	D=1.65		B=17.82
E=4.30	C=1.01	A=1.85	A=2.26	C=1.63	D=0.95	A=1.64		A=17.20
B=3.90	D=0.93	B=1.81	C=2.25	A=1.62	A=0.92	E=1.50		E=17.01
A=3.72	E=0.90	D=1.77	B=2.21	B=1.57	C=0.90	B=1.47		C=16.16
D=3.66	B=0.87	C=1.62	D=2.18	E=1.51	B=0.89	C=1.44		D=15.79

12-17-26	12-31-26	1-14-27	1-28-27	2-11-27	2-25-27	3-11-27
18-WKS.	20-WKS	22-WKS.	24-WKS	26-WKS	28-WKS.	30-WKS.
C=35.14	E=42.73	A=74.25	A=170.[illegible]	A=113.14	A=97.13	B=85.28
E=32.85	A=40.60	E=63.69	B=136.07	B=99.71	B=87.28	E=78.98
A=32.59	D=39.73	B=61.69	C=121.30	C=96.70	D=83.16	A=77.66
D=32.45	B=31.03	D=57.11	D=121.10	E=93.60	C=81.47	C=76.21
B=32.20	C=28.09	C=56.18	E=112.37	D=91.34	E=80.00	D=71.03

* TOO STORMY TO TAKE COUNTS.

Fig. 1

there were 50 plots, each plot containing ten 30-foot lines of cane. All plots received identical fertilizer and cultivation practices. Of these 50 plots, 10 were irrigated at 15-day intervals. Ten alternating plots were irrigated first with one 15-day interval and then the intervals between irrigation applications were increased to 30 days. Ten additional plots were irrigated, first with one 15-day interval, then one 30-day interval, from then on at 45-day intervals. Ten additional plots were irrigated, first at 15-, then at 30-, then at 45- and finally at 60-day intervals. The fifth series consisting of 10 additional plots, was irrigated first at 15-, then at 30-, 45-, 60- and finally at 90-day intervals. The arrangement of plots is shown in the lower part of Fig. 2.

It will be seen therefore, that the cane was not suddenly cut off from water in any of the series, but a process of tapering off on irrigation applications was inaugurated, to bring the longest intervals between applications in the period expected to be most favorable for eye spot infection. In the case of a rain which was equal to an irrigation application, no water was applied to the experiment at that time. Rainfall from light showers was disregarded, however. All plots received the first irrigation application of the experiment on August 15, 1926.

In each plot 20 stalks were marked with a red cloth for future identification, and at two-week intervals the number of eye spot infections were counted on the third youngest leaf of each of these stalks. Since there were ten plots of each treatment, there were thus 200 leaves from which the numbers of infections were averaged per leaf.

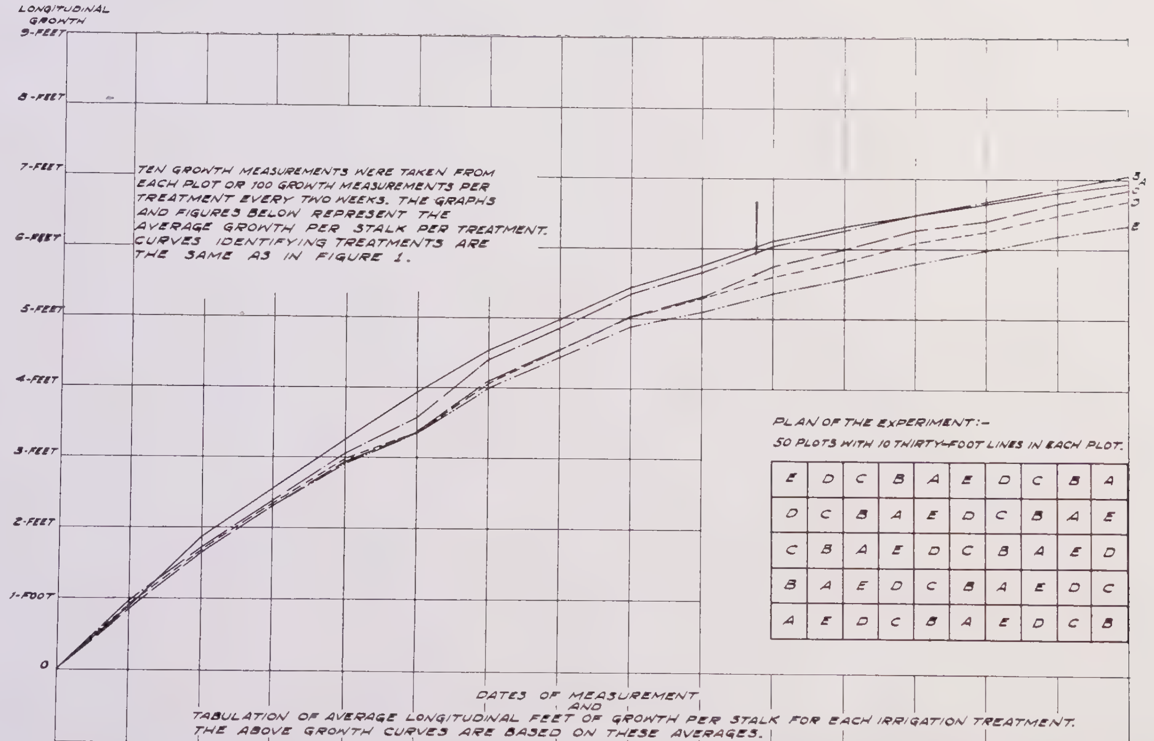
The increase in eye spot in each series of plots during the winter months, is shown in Fig. 1.

By reference to Fig. 1, one sees that eye spot infection was negligible and averaged less than 2 infections per leaf during August, September, October and early November. On November 5 infection started to increase and reached the peak, in this field, on January 28, averaging 170 infections per leaf. During this time, the plots receiving irrigation at 15-day intervals showed more eye spot per leaf consistently. At the peak of infection there were 34 infections per leaf more in such plots than in the plots receiving water at 30-day intervals, a difference amounting to 20 per cent. There were 49 more infections per leaf than in the plots receiving water at 45- and 60-day intervals, a difference amounting to 28 per cent. With water at intervals greater than 45 days there was but slight reduction in infection, in this experiment.

Since there were ten replications of the plots for each irrigation treatment, the results should be accurate. It seems a safe conclusion that lessening irrigation to 45-day intervals between applications, materially reduced eye spot. A decrease amounting to 34 or 49 infections per leaf such as was obtained is often the difference between complete top rot of the cane, and leaf infection from which the cane quickly recovers.

Turning to the growth in the plots of the various irrigation series, shown in Fig. 2, it can be seen that on March 11, at the end of the experiment, the cane in B plots in which the irrigation was lessened to applications at 30-day intervals, actually showed more longitudinal growth per stalk than the cane in plots

FIG. 2:- THE EFFECT UPON CANE GROWTH OF DECREASING THE FREQUENCY OF IRRIGATION APPLICATIONS IN EYE SPOT FIELDS



8-13-26	8-27-26	9-10-26	9-24-26	10-8-26	10-22-26	11-5-26	11-19-26	12-3-26	12-17-26	12-31-26	1-14-27	1-28-27	2-11-27	2-25-27	3-11-27
	2-WKS.	4-WKS.	6-WKS.	8-WKS.	10-WKS.	12-WKS.	14-WKS.	16-WKS.	18-WKS.	20-WKS.	22-WKS.	24-WKS.	26-WKS.	28-WKS.	30-WKS.
	B=0.95	A=1.87	A=2.56	A=3.24	A=3.91	A=4.53	A=4.97	A=5.41	A=5.72	A=6.10	A=6.30	A=6.49	B=6.67	B=6.86	B=7.03
	D=0.91	B=1.71	B=2.40	B=3.05	B=3.57	B=4.39	B=4.85	B=5.31	B=5.63	B=6.04	B=6.25	B=6.47	A=6.64	A=6.80	A=6.94
	A=0.88	D=1.69	D=2.34	D=2.98	D=3.37	C=4.10	C=4.55	C=5.00	C=5.29	C=5.75	C=5.98	C=6.27	C=6.40	C=6.63	C=6.83
	C=0.88	E=1.65	E=2.32	C=2.94	C=3.37	D=4.06	D=4.53	D=5.00	D=5.27	D=5.60	D=5.83	D=6.08	D=6.26	D=6.49	D=6.68
	E=0.86	C=1.64	C=2.32	E=2.92	E=3.34	E=3.98	E=4.43	E=4.88	E=5.09	E=5.36	E=5.54	E=5.78	E=5.97	E=6.18	E=6.34

Fig. 2

with 15-day interval water. On the other hand, the cane in plots in which the water was tapered off to a 90-day interval between applications lost 7⅕ inches of growth as compared with the cane irrigated at 15-day intervals. This is obviously too great a loss to be compensated for by the reduced eye spot. However, if one analyzes the growth chart throughout the season other conclusions can be drawn. Running backward over the growth curves to December 31, one sees that the loss in growth on that date amounted to 8.9 inches in growth, a greater loss than occurred at the end of the experiment. In other words, after December 31 the cane with 90-day intervals between irrigation actually gained in longitudinal growth on the cane with 15-day interval water. This is equally true of the cane in plots with 60-, 45- and 30-day intervals between irrigations; the cane in all of these plots gained in growth during the cold months, as compared with the cane in the plots with 15-day interval water.

The autumn months of 1926 were warm, with unusually high temperatures recorded for these months. During these warm months the growth in plots with 15-day interval irrigation applications exceeded in growth the plots with lessened irrigation. But with the lowering in temperatures, the growth curve of the plots with 15-day irrigation, flattened off and the growth was better in all of the plots with lessened irrigation.

These results support the conclusions advanced by George F. Renton and William P. Alexander at the last annual meeting of the Association (1926), at which they presented growth results with maximum, moderate and minimum applications of water. They found that in the winter months better growth resulted from the minimum applications of irrigation.

If one were to analyze the growth curves in Fig. 1, still further, one would conclude that if the curves for the 30- and 45-day irrigation (B or C) were cut off on the December 31 date line and superimposed on the 15-day irrigation curve (A), more growth would have resulted than was obtained in any of the series.

The conclusion from an agricultural viewpoint alone, independent of the viewpoint of disease control, would seem to be that less irrigation in the winter months will result in greater cane growth. From our temperature data, the conclusions would be drawn that this lessened irrigation should not be based on the month of the year, but on the temperatures being recorded at the time, as well as the rainfall. Winds or absence of winds are also undoubtedly a large factor to be considered in this matter of frequency of irrigation in the winter months, in relation to cane growth and eye spot occurrence.

Summary

Based on an experiment with ten replications of plots, with 200 leaf counts for eye spot intensity and 100 growth measurements for each treatment, the following conclusions seem evident:

(1) Decreasing irrigation by lengthening the intervals between applications definitely lessened the amounts of eye spot infection. A cane with 90 to 100 infections per leaf is much more probable to succumb to top rot than a cane with

60 to 70 infections per leaf. Such a difference was obtained with lessened irrigation, and is thus sufficient to avoid much of the serious loss from top rot.

(2) Such lessened irrigation lessened longitudinal growth during the warm months, but increased growth during the cold months.

(3) It seems reasonable to believe that discretion in the use of irrigation, watching closely the temperatures being recorded during the season, the wind movement, as well as the rainfall, may be made to minimize eye spot and increase cane growth.

Experiment laid out and conducted by J. P. Martin with the cooperation of the Waialua Agricultural Co., Ltd.

Experiment planned by H. Atherton Lee.

H. A. L.

The Effect of Frequency of Irrigation Applications on Eye Spot at the Lihue Plantation Company, Ltd.

The effect of lessening the frequency of irrigation applications upon the severity of eye spot was tested out in an experiment at the Lihue Plantation Company. The experiment was laid out in Field Lihue 4, of H 109, first ratoons, 1928 crop. All plots received identical fertilizer and cultivation treatments, the only variables being in the intervals between irrigation applications. Due to the exigencies of the field layout but one plot per treatment was possible in this field.

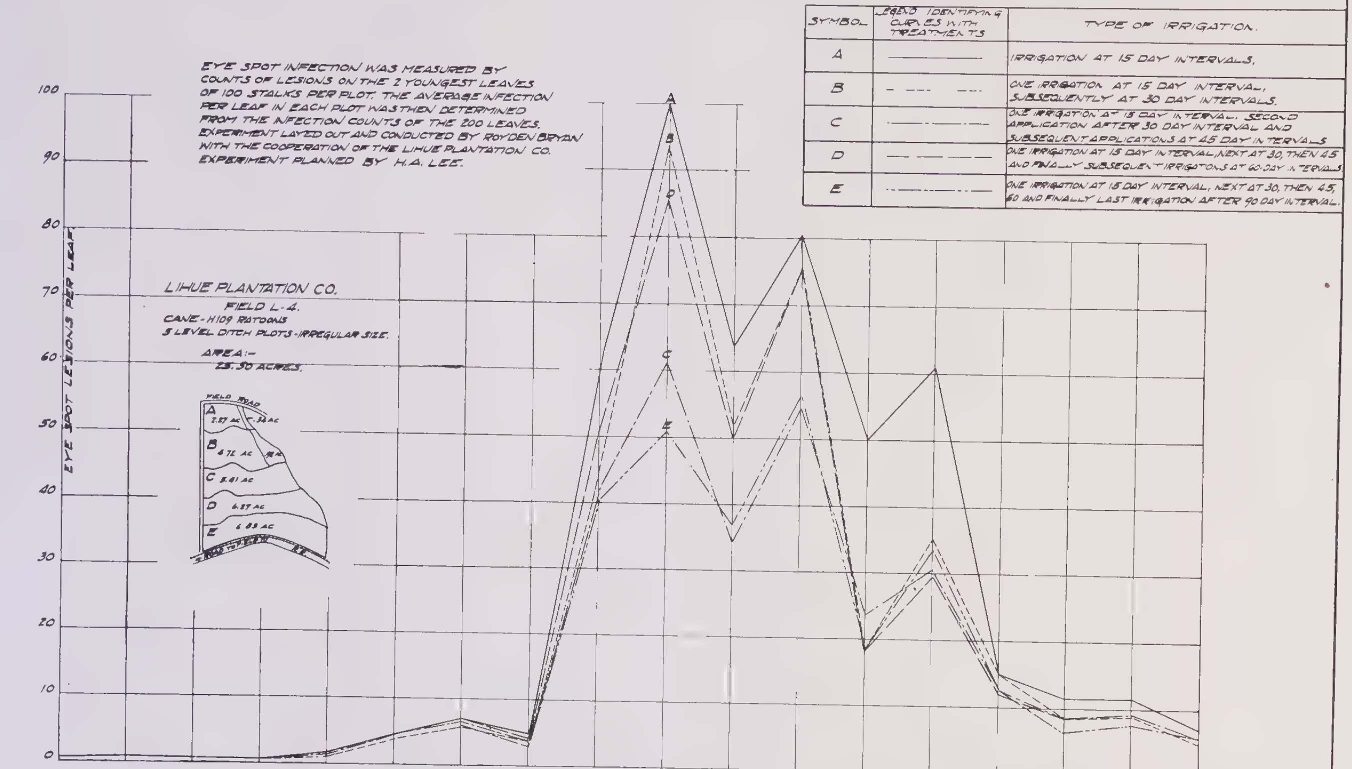
The irrigation treatments were as follows: Plot A received water at 15-day intervals. Plot B received water, first following one 15-day interval, and thereafter at 30-day intervals. Plot C received water first following one 15-day interval, next following one 30-day interval and thereafter at 45-day intervals. Plot D received water first following one 15-day interval, then after a 30-day interval, a 45-day interval and then at 60-day intervals. Plot E received water first following one 15-day interval, then after one 30-day interval, 45-, 60-, and finally a 75-day interval. The attempt was made in these irrigation applications, to avoid the abrupt discontinuance of water, but to gradually taper off the water applications. This is the practice which has been successful against eye spot at the Oahu Sugar Company for several years.

The layout of the experiment is shown in Fig. 1.

The degree of eye spot infection was determined from 200 leaf counts per treatment; the two youngest leaves on 100 stalks per treatment were used to secure the average infection per leaf. The average numbers of infections per leaf throughout the season are charted in Fig. 1.

Growth measurements were taken from 100 stalks per plot and are charted in Fig. 2.

FIG. 1 :— THE EFFECT OF THE FREQUENCY OF IRRIGATION APPLICATIONS ON EYE SPOT



TABULATED FIGURES SHOWING AVERAGE NUMBER OF INFECTIONS PER LEAF FOR EACH TREATMENT.

(8-23-26)	2 WKS. (9-6-26)	4 WKS. (9-20-26)	6 WKS. (10-4-26)	8 WKS. (10-18-26)	10 WKS. (11-1-26)	12 WKS. (11-15-26)	14 WKS. (11-29-26)	16 WKS (12-13-26)	18 WKS (12-27-26)	20 WKS (1-10-27)	22 WKS. (1-24-27)	24 WKS (2-7-27)	26 WKS (2-21-27)	28 WKS (3-7-27)	30 WKS (3-21-27)	32 WKS (4-5-27)	34 WKS (4-19-27)
	A = .78	A = .48	A = .51	A = 1.54	A = 4.34	A = 6.81	A = 4.68	A = 59.7	A = 99.39	A = 63.46	A = 80.49	A = 49.62	A = 60.80	A = 14.97	A = 11.25	A = 11.31	A = 6.85
	B = .78	B = .62	B = .54	B = .96	B = 3.64	B = 5.40	B = 3.64	B = 45.0	B = 93.78	B = 51.48	B = 75.55	B = 18.22	B = 35.03	B = 14.81	B = 8.42	B = 8.78	B = 4.87
	C = .98	C = .76	C = .61	C = 1.32	C = 4.20	C = 6.48	C = 3.68	C = 41.96	C = 61.24	C = 34.03	C = 54.73	C = 23.26	C = 30.29	C = 12.67	C = 8.43	C = 9.24	C = 5.79
	D = .88	D = .68	D = .62	D = 1.46	D = 3.76	D = 7.00	D = 4.01	D = 51.25	D = 85.59	D = 49.85	D = 75.37	D = 17.92	D = 29.24	D = 11.91	D = 8.79	D = 9.12	D = 5.68
	E = 1.19	E = .55	E = .50	E = 1.26	E = 3.01	E = 5.91	E = 2.96	E = 40.30	E = 51.80	E = 36.85	E = 56.73	E = 18.53	E = 33.56	F = 12.23	E = 6.26	E = 7.88	E = 5.77

Fig. 1

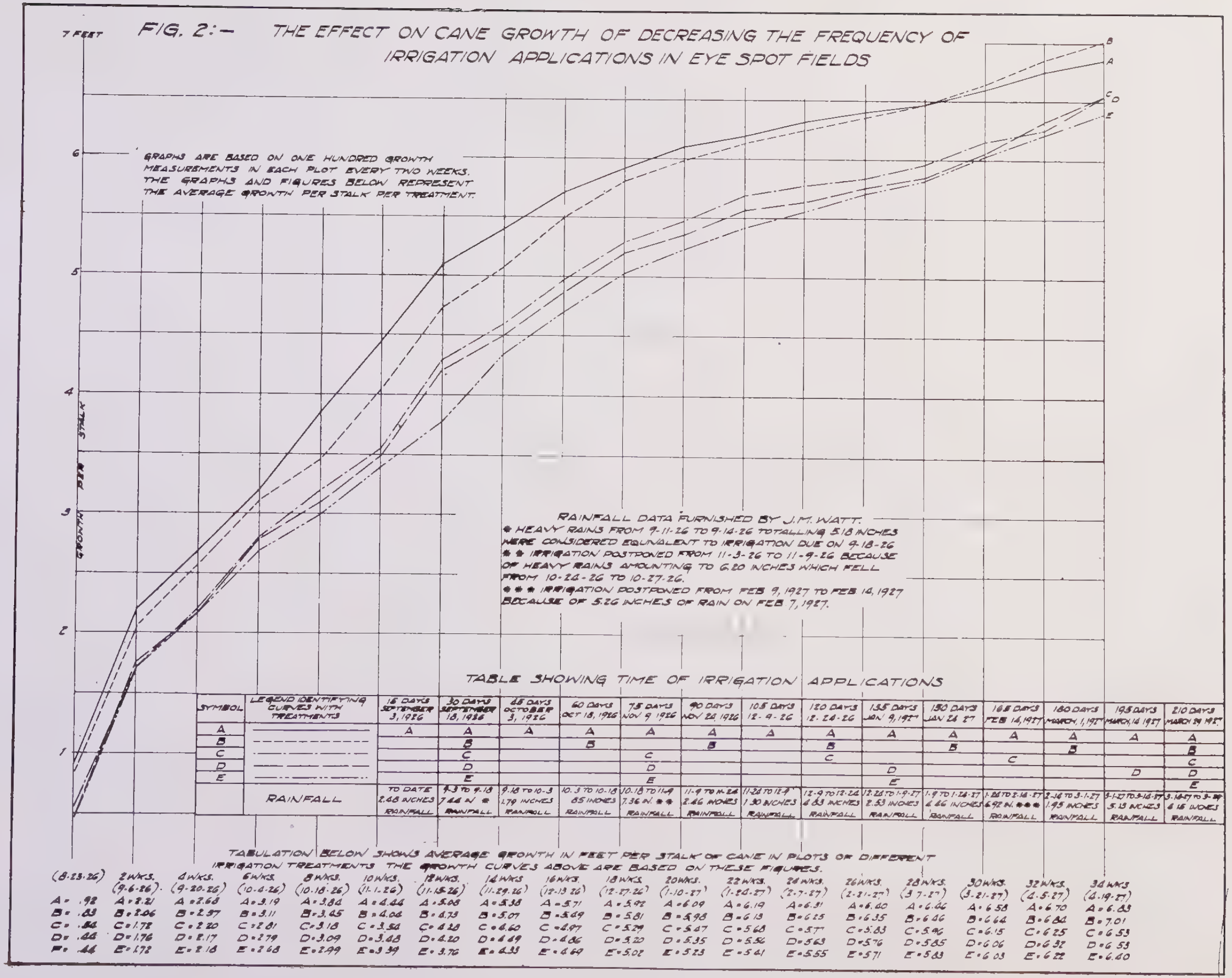


FIG. 2:— THE EFFECT ON CANE GROWTH OF DECREASING THE FREQUENCY OF IRRIGATION APPLICATIONS IN EYE SPOT FIELDS
7 FEET
6
5
4
3
2
1
GROWTH PER STALK
A
B
C
D
E
GRAPHS ARE BASED ON ONE HUNDRED GROWTH MEASUREMENTS IN EACH PLOT EVERY TWO WEEKS. THE GRAPHS AND FIGURES BELOW REPRESENT THE AVERAGE GROWTH PER STALK PER TREATMENT.
RAINFALL DATA FURNISHED BY J.M. WATT.
* HEAVY RAINS FROM 9-11-26 TO 9-14-26 TOTALLING 5.18 INCHES WERE CONSIDERED EQUIVALENT TO IRRIGATION DUE ON 9-18-26
** IRRIGATION POSTPONED FROM 11-3-26 TO 11-9-26 BECAUSE OF HEAVY RAINS AMOUNTING TO 6.20 INCHES WHICH FELL FROM 10-24-26 TO 10-27-26.
*** IRRIGATION POSTPONED FROM FEB 9, 1927 TO FEB 14, 1927 BECAUSE OF 5.26 INCHES OF RAIN ON FEB 7, 1927.
TABLE SHOWING TIME OF IRRIGATION APPLICATIONS
SYMBOL
LEGEND IDENTIFYING CURVES WITH TREATMENTS
15 DAYS SEPTEMBER 3, 1926
30 DAYS SEPTEMBER 18, 1926
45 DAYS OCTOBER 3, 1926
60 DAYS OCT 18, 1926
75 DAYS NOV 9 1926
90 DAYS NOV 24, 1926
105 DAYS 12-9-26
120 DAYS 12-24-26
135 DAYS JAN 9, 1927
150 DAYS JAN 24 27
165 DAYS FEB 14, 1927
180 DAYS MARCH, 1, 1927
195 DAYS MARCH, 16 1927
210 DAYS MARCH 31 1927
RAINFALL
TO DATE 2.48 INCHES RAINFALL
9-3 TO 9-18 7.44 IN * RAINFALL
9-18 TO 10-3 1.79 INCHES RAINFALL
10-3 TO 10-18 .85 INCHES RAINFALL
10-18 TO 11-9 7.36 IN. ** RAINFALL
11-9 TO 11-24 2.46 INCHES RAINFALL
11-24 TO 12-9 1.30 INCHES RAINFALL
12-9 TO 12-24 4.83 INCHES RAINFALL
12-24 TO 1-9-27 2.53 INCHES RAINFALL
1-9 TO 1-24-27 4.46 INCHES RAINFALL
1-24 TO 2-14-27 6.92 IN. *** RAINFALL
2-14 TO 3-1-27 1.95 INCHES RAINFALL
3-1-27 TO 3-16-27 5.13 INCHES RAINFALL
3-16-27 TO 3-31 6.15 INCHES RAINFALL
TABULATION BELOW SHOWS AVERAGE GROWTH IN FEET PER STALK OF CANE IN PLOTS OF DIFFERENT IRRIGATION TREATMENTS THE GROWTH CURVES ABOVE ARE BASED ON THESE FIGURES.
(8-23-26) A = .92 B = .83 C = .84 D = .84 E = .84
2 WKS. (9-6-26) A = 2.21 B = 2.06 C = 1.78 D = 1.76 E = 1.72
4 WKS. (9-20-26) A = 2.68 B = 2.57 C = 2.20 D = 2.17 E = 2.16
6 WKS. (10-4-26) A = 3.19 B = 3.11 C = 2.81 D = 2.79 E = 2.68
8 WKS. (10-18-26) A = 3.84 B = 3.45 C = 3.18 D = 3.09 E = 2.99
10 WKS. (11-1-26) A = 4.44 B = 4.04 C = 3.54 D = 3.48 E = 3.39
12 WKS. (11-15-26) A = 5.08 B = 4.73 C = 4.28 D = 4.20 E = 3.76
14 WKS. (11-29-26) A = 5.38 B = 5.07 C = 4.60 D = 4.49 E = 4.33
16 WKS. (12-13-26) A = 5.71 B = 5.49 C = 4.97 D = 4.86 E = 4.69
18 WKS. (12-27-26) A = 5.92 B = 5.81 C = 5.29 D = 5.20 E = 5.02
20 WKS. (1-10-27) A = 6.09 B = 5.98 C = 5.47 D = 5.35 E = 5.23
22 WKS. (1-24-27) A = 6.19 B = 6.13 C = 5.68 D = 5.56 E = 5.41
24 WKS. (2-7-27) A = 6.31 B = 6.25 C = 5.77 D = 5.63 E = 5.55
26 WKS. (2-21-27) A = 6.40 B = 6.35 C = 5.83 D = 5.76 E = 5.71
28 WKS. (3-7-27) A = 6.46 B = 6.46 C = 5.96 D = 5.85 E = 5.83
30 WKS. (3-21-27) A = 6.58 B = 6.64 C = 6.15 D = 6.06 E = 6.03
32 WKS. (4-5-27) A = 6.70 B = 6.84 C = 6.25 D = 6.32 E = 6.22
34 WKS. (4-19-27) A = 6.83 B = 7.01 C = 6.53 D = 6.53 E = 6.40

Fig. 2.

From the eye spot graphs in Fig. 1, it can be seen that eye spot infections average less than one per leaf in all plots in the experiment, up to October 4, 1926. Although eye spot then increased gradually, there was no severe increase until November 29. Thereafter there was an abrupt increase in eye spot, reaching the worst peak of infection on December 22, but with two later peaks on January 24, 1927, and February 21. New infections in this field were not severe after March 7.

At all peaks of infection, the cane irrigated throughout the season at 15-day intervals showed the most eye spot. At the first peak of infection the difference between the 15-day interval plots, and the 45-day interval plots amounted to 38 infections per leaf; at the second peak the difference amounted to 26 infections, and at the third peak the difference amounted to 30 infections per leaf. The relative amounts of eye spot infection in the plots with 30-day interval water, 45-, 60- and 75-day interval water were not consistent and the probable explanation is the lack of replications of plots, causing the plots with situations more favorable for infection to show more eye spot in some instances regardless of the frequency of irrigation applications. In general, however, it is evident that the plots with irrigation at greater intervals, showed less eye spot than these plots with frequent irrigations, the lessened eye spot in many cases being the difference between top rot and mere leaf infection.

Our greatest concern, however, was with the rate of growth of the cane under the different irrigation treatments. The plots throughout the early part of the experiment, maintained consistent positions as to growth, the 15-day interval plots exceeding the 30-day plots, which in turn exceeded the 45-day plots, then the 60-day plots, with the least growth in the 75-day interval plots. On November 15 these differences in growth were so great as to indicate that lessening eye spot by decreasing irrigation was at much too large a sacrifice of cane growth.

However, one will recall that the autumn months of 1926 were unusually warm and summer weather existed well into November. With the occurrence of low temperatures in late November and winter months, the growth curve of the cane in the 15-day interval plots flattened off appreciably, while the cane in the less frequently irrigated plots gained appreciably in growth. Thus whereas on November 15 there was a difference of 4.2 inches growth per stalk in favor of the 15-day interval plots as compared with the 30-day plots, on March 19 the 30-day plots had gained on the 15-day plots to such an extent that there was a greater growth of 2.1 inches per stalk in the B plots than in the A plots. Whereas on November 15 the difference in growth between the 15-day interval plots and the 75-day interval plots was 10 inches per stalk (allowing for the difference in growth per stalk in the two plots at the inception of the experiment), on March 19, the cane in the 75-day interval plots had entirely recovered the lost growth per stalk, made previous to November 15.

From an agricultural viewpoint these results are fully as interesting as from the viewpoint of their relation to cane diseases, for they indicate that at low temperatures, and with frequent rainfalls, considerable growth can be lost by over irrigation. Undoubtedly the occurrence or absence of winds constitute a considerable factor in determining the intervals to elapse between irrigation applica-

tions. The results indicate that eye spot can be lessened by increasing the time intervals between irrigation applications, without serious loss in cane growth and even with an increase in cane growth.

It is evident that no rule of thumb can be laid down for the administration of irrigation water in eye spot areas, in the winter months. However, keeping in mind temperatures being recorded at the time, the occurrence of wind, as well as rainfall, the exercise of discretion may be made to increase cane growth, decrease eye spot, and cut down on irrigation charges.

Summary

(1) Lessening the frequency of irrigation applications in the winter months materially lessened the severity of eye spot.

(2) Such lessened irrigation decreased cane growth in the warm months, but increased cane growth in the cooler winter months, when abundant rainfall also occurred. Cane with irrigation at 30-day intervals showed 4.2 inches less growth per stalk than the cane with the 15-day interval irrigation on November 15, but showed 2.1 inches more growth per stalk at the end of the experiment on March 19, 1927. Temperature, and possibly the absence of winds, as well as rainfall, seem to be the principal factors in bringing about this increased growth with lessened irrigation applications.

Experiment laid out and conducted by Royden Bryan, with the cooperation of the Lihue Plantation Co., Ltd.

Experiment planned by H. Atherton Lee.

H. A. L.

The Susceptibility to Eye Spot of H 109 Ratoons as Compared With Plant Cane

It has usually been considered that H 109 ratoons were less susceptible to eye spot than plant cane. It has been difficult to obtain a clear-cut comparison from field observations, however, since slight differences in age of cane, time of fertilizer applications and amounts of irrigation water introduce other variables than the difference between plant and ratoons.

During the past eye spot season, it was possible at the Lihue Plantation Company to make a careful experimental comparison of the susceptibility of plant cane as against ratoons. In a field of recently cut H 109 stubble, 20 plots were laid out, each of approximately 5 rows, each row 35 feet in length; in ten of these 20 plots, the stubble was dug out and H 109 cuttings replanted in place of the stubble. In the ten alternating plots the stubble was allowed to continue growth as first ratoons. The plots thereafter received identical irrigation, fertilizer and cultivation practices. The layout of the experiment is shown in Fig. 1.

FIG. 1:— THE COMPARATIVE SUSCEPTIBILITY TO EYE SPOT OF H 109 PLANT CANE AND RATOONS

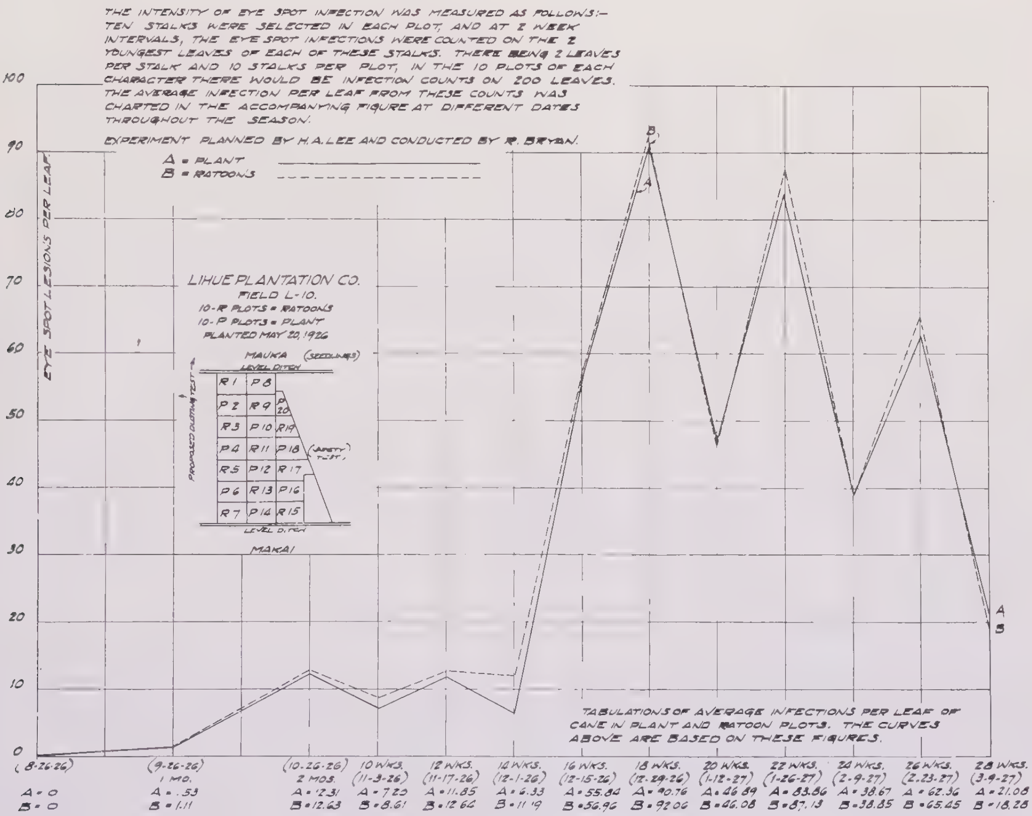
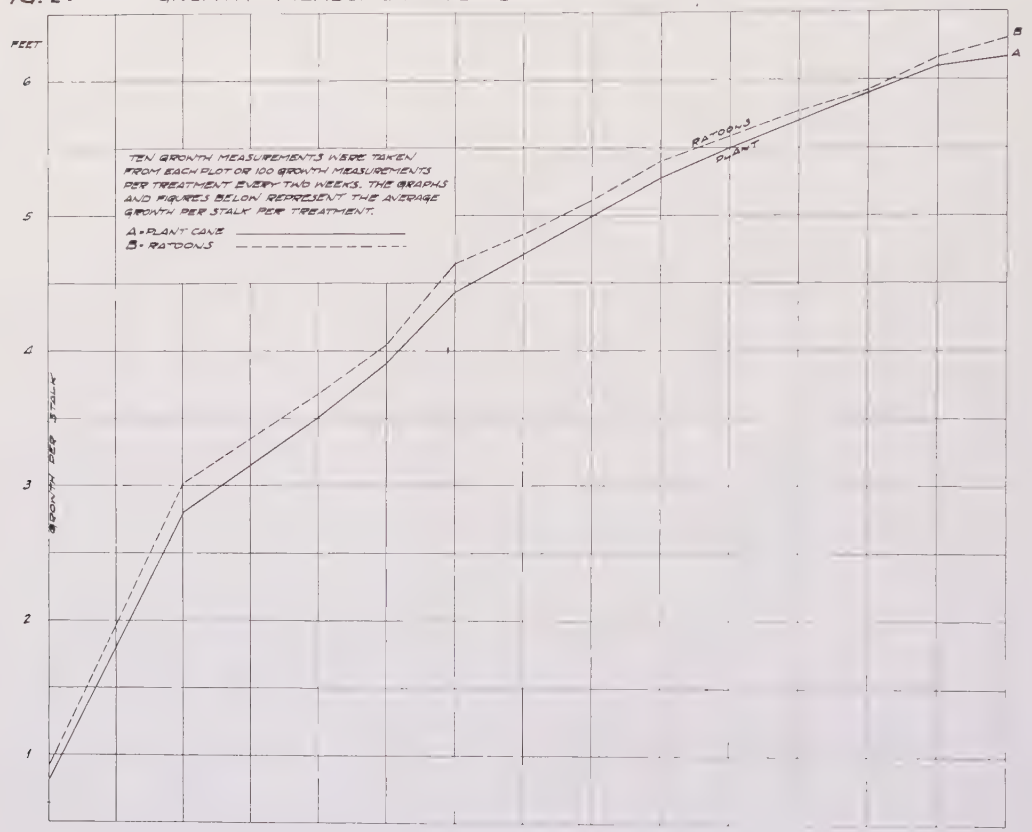


Fig. 1

FIG. 2:— GROWTH MEASUREMENTS OF H 109 PLANT CANE VERSUS RATOONS



TABULATION OF AVERAGE GROWTH IN FEET PER STALK OF CANE IN PLANT AND RATOON PLOTS. THE CURVES ABOVE ARE BASED ON THESE FIGURES.

	1 MO.	2 MO'S.	10 WKS.	12 WKS.	14 WKS.	16 WKS.	18 WKS.	20 WKS.	22 WKS.	24 WKS.	26 WKS.	28 WKS.
(8-26-26)	(9-26-26)	(10-26-26)	(11-3-26)	(11-17-26)	(12-1-26)	(12-15-26)	(12-29-26)	(1-12-27)	(1-26-27)	(2-9-27)	(2-23-27)	(3-9-27)
A = .80	A = 2.80	A = 3.49	A = 3.90	A = 4.43	A = 4.71	A = 4.98	A = 5.27	A = 5.48	A = 5.70	A = 5.90	A = 6.09	A = 6.16
B = .89	B = 3.01	B = 3.67	B = 4.03	B = 4.64	B = 4.86	B = 5.11	B = 5.39	B = 5.57	B = 5.76	B = 5.92	B = 6.16	B = 6.29

Fig. 2.

Counts were made of the numbers of infections on the two youngest leaves of each of ten stalks in each plot. Such stalks were then marked for future identification and subsequent infection counts. Since there were ten replications of each character of plot with ten stalks per plot and two leaves counted per stalk, there were thus 200 leaves upon which infection counts were made and averaged per leaf for the plant cane; an equal number were made for the ratoons. There were ten growth measurements taken in each plot, or 100 growth measurements for each character of plot. Counts of leaf infections and growth measurements were repeated at two-week intervals.

The development of the disease during the winter months is shown in Fig. 1; the longitudinal growth per stalk is shown in Fig. 2.

The graphs in Fig. 1 show that in this field eye spot infections averaged less than 1 per leaf up to September 26, and less than 13 per leaf up to December 1. Thereafter there was then a rapid increase in eye spot. The graphs show the eye spot outbreaks in this field which were typical of many fields on Kauai this year, with not one peak but several recurring with each new occurrence of bad eye spot weather.

The remarkable result in this experiment is the close coherence of the graph for eye spot infection of plant cane with the graph showing infection of the first ratoons.

Conclusions

(1) The conclusion seems quite definite that there are no differences in susceptibility to eye spot between H 109 plant cane and ratoons under identical treatment.

(2) There were no significant differences in longitudinal growth per stalk, between the plant cane and first ratoons.

(3) Aside from their bearing on the susceptibility of plant cane as compared with ratoons, the graphs show the accuracy of such eye spot counts, for eye spot was apparently being counted in plots of identical susceptibility, and the close coherence of the graph for the infection on the ratoons, with the graphs for infection on plant cane, indicates the reliability of this method of measuring eye spot intensity.

Experiment laid out and conducted by Royden Bryan with the cooperation of The Lihue Plantation Company, Limited.

Experiment planned by H. Atherton Lee.

H. A. L.

Lime*

There was a time when most industries thought they had learned all that it was necessary to learn about lime for their particular purposes when they had secured the chemical analysis and the price. Today we are just beginning to appreciate that there are many physical variations in the different limes and their products due to differences in the structure of the original rock, in the methods of burning and in the manner of its slaking or hydration, which will cause wide variations in its adaptability to the many industries now using it as a raw material. The same lime rock, sized and burned in two different ways, both methods being standard practices in various plants in this country, has shown a difference of 40 per cent in the effectiveness of its use in a specific industry, and this in spite of the fact that the high efficiency lime showed by chemical analysis 2 per cent less available oxides.

In many industries lime has not received the study it should have to determine the particular characteristics needed for maximum benefit. This has probably been due to its cheapness, which has doubtless caused many of the consumers to frown upon its importance and to ignore its variations. It is hoped that this symposium will arouse the technical men and the executives in the lime industry and many of the chemical industries using lime to the importance of further investigation, and above all to the need of practical and friendly cooperation between the modern lime manufacturer with his technical staff and those responsible for improving the manufacture and control of practices in the industries using lime.

Lime manufacturing in its simplest form merely involves quarrying lime rock from general strata, passing this material in its crude form through an oven which will stand temperatures up to about 2300° F., and then shoveling this product into a car for shipment.

Lime manufacturing as perfected in some modern plants involves:

(1) Careful selection of the rock strata that appear in every limestone deposit in order to use for burning only such grades as are specifically suited for the known chemical, building, or agricultural uses for which the lime is to be sold.

(2) Proper sizing of the rock to give uniformity of burning in the particular type of kiln being used and under the particular method of burning employed.

(3) Maintenance of steady heat application for uniform and understood periods in order to produce that quality of burnt lime required for the particular trade, and of as nearly uniform quality as modern experience provides in plant control.

(4) Maintenance of those conditions for hydration which are found to produce the desired characteristics in each lime.

(5) Thorough and continuous chemical and physical control of all these steps by skilled laboratory supervision.

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* Extracts from the Lime Symposium presented before the Division of Industrial and Engineering Chemistry, American Chemical Society, Richmond, Virginia, April 11-16, 1927, as published in the *Industrial and Engineering Chemistry,* Vol. 19, No. 5.

Lime manufacturing has become a highly specialized chemical industry, though many do not yet recognize this fact. The methods still pursued in many quarters where the highest grade chemical limes should be manufactured, and the lack of understanding and specifications on the part of many users give evidence of this (1).

Calcination is the most important process in the manufacture of lime. Much progress has been made in overcoming the crudities of the early lime kilns. Increased kiln efficiency has been brought about in several ways as follows:

The shape and sizes of kilns have been modified to accommodate a large tonnage of stone, and to give maximum draft with a minimum of waste heat; also coolers have been so designed that the heat of the burned lime is largely conserved.

The better types of modern kilns are so insulated that there is little heat loss through the shell.

The type of fuel to be used, the arrangement of fire boxes, the time and manner of firing and methods of forced or induced draft, have been studied, and many improvements have been worked out.

Both steam and carbon dioxide, introduced beneath the grates, are employed to control draft and temperature in the fuel bed.

One of the most remarkable developments in the lime industry is the great increase in the manufacture of hydrated lime. From 30 plants producing 120,000 tons in 1906, this branch has grown to 134 plants producing over 1,500,000 tons in 1925. Although used chiefly in the building trades, it also finds wide use in agriculture and for chemical applications. Hydrated lime prepared at the lime plant is advantageous to the user, because with the employment of special equipment under exact control it is more completely hydrated, of greater purity, and in better physical condition than can usually be attained by the cruder hydration methods commonly employed at points of consumption.

From a few well-known uses that could be counted on the fingers of one hand, the uses of lime have so multiplied that they may now be numbered in the hundreds. When lime is applied to various highly specialized uses it is natural that the required properties will vary. This has led to a broad study of the specific requirements of lime for various uses, and to the establishment of fixed standards. The American Society for Testing Materials, the Bureau of Standards, and the National Lime Association have devoted much study to such problems and many specifications are now available.

As a consequence of the exacting requirements much study has been devoted to the properties of lime in their relation to the original limestone, to temperature and time of burning, effects of impurities, calcination equipment, and methods of hydration. Naturally, these two lines of inquiry, the development of specifications and the broader knowledge of the properties of lime, go hand in hand, for the one outlines the qualities desired for given uses and the other determines the methods of selection and manufacture that must be pursued to satisfy most fully the requirements of the consuming industries.

A greatly increased knowledge has been gained of the physical and chemical properties of lime through the researches of the Bureau of Standards and the various fellowships established by the National Lime Association.

It is generally recognized today that physical as well as chemical properties of the original limestone may have a profound influence on behavior during calcination, on cost of manufacture, and on the use of the finished lime. Thus, porous limestones and coarsely crystallized limestones tend to break up greatly during the burning process. Porous limestones may contain water in quantities that demand an appreciable amount of heat for removal. Heat readily penetrates dense, non-porous stones, in consequence of which they may be calcined in a shorter period of time than the loose-textured or porous stones. The complexity of lime-burning is increased by the fact that limestones in no two deposits are exactly alike. Just as in a crowd of one thousand human beings no two faces are alike, so the stone of every deposit has its own individuality. Differences in grain size, in texture, in mode of crystallization, in hardness, in porosity, density, color, or impurities all have their influence in some degree, and thus a new lime-burning enterprise is always experimental in its early stages.

It is well known also that the method of manufacture has a profound influence on the character of the lime produced. Lime manufactured in the rotary kiln is totally different from lime made of the same stone in a shaft kiln. It has been found that limestone calcined in a sintering machine in the short period of 30 to 40 minutes gives a lime which hydrates with extreme rapidity (2).

Liming the soil is recognized as necessary in crop production over vast areas of the humid region. There has been much investigation of the various phases of the liming problem. An important issue centers around the rate of soil treatment. Just how efficient is lime when applied in graduated rates?

According to Truog, the intake of food lime (calcium) by plants appears to be conditional upon the reaction of the soil solution. Whenever the soil solution becomes more acid than the sap of the plant, the crop takes in its food calcium with difficulty. Each kind of crop plant possesses an intrinsic sap acidity. Some, notably alfalfa, are characterized by a weak acidity while others are strongly acid.

The purpose of liming a so-called acid soil is to reduce its reaction to a point milder than the internal acidity of the crop plant to be grown. On a soil of given reaction the magnitude of change necessary to meet the requirement of a specific crop, depending on its sap reaction, may be small or even nil. For another crop, one of mild sap acidity, the relative range could be wide. For the one little lime is needed, for the other much may be necessary to shift the reaction to the point affording the preferred ease and rapidity of lime intake by the plant.

For no farm crop is it necessary to lime a soil to the point of neutrality. All crop plants grow successfully on the acid side of the neutral point. A wide difference in preference is noted, however. Alfalfa and sweet clover exhibit difficulty when the soil reaction falls below 6.5 pH. A drop of less than one pH below this level proves extremely injurious. The purpose of adding liming material to the soil is therefore to raise the reaction toward the preferment of the crop (3).

(1) From a paper by Charles Warner.
(2) From a paper by Oliver Bowles.
(3) From a paper by John A. Slipher.

(W. L. McC.)

Watch the Bottom Blow-off on Your Boiler!*

By F. A. Page

Only too often is this very important appurtenance of a steam boiler neglected, very little care and attention being given to it, as its importance and usefulness is not understood by the average attendant. Instead of being used to insure the safe and proper operation of the boiler, it is allowed to become inoperative and thus a source of danger to both the attendant and all in the vicinity.

From reports of inspection one can readily see that this appurtenance is the most neglected and abused of all the different appliances on a boiler and has caused many accidents, both fatal and otherwise.

To enumerate all the different causes of blow-off failures on record would be too voluminous, but the principal causes appear to be as follows:

1. Allowing the blow-off pipe to become clogged with mud or scale, and also to be exposed to the products of combustion. This causes overheating, oxidizing, rupture, or total disintegration of the metal in the pipe, and results in a sudden release of hot water under boiler pressure;

2. Improper and neglected fittings are another source of danger. Common service cocks, such as are used in water service, having neither yoke nor gland to hold plug in place, have been the cause of many accidents in the past. The cohesion of the bottom nut and washer caused the bottom stud to be twisted off and allowed the plug to be blown out of the body by the boiler pressure;

3. Broken blow-off pipe and fittings, from either too rapid opening of valves or cocks (producing shocks), or by the indiscriminate use of long wrenches on plug cocks breaking the pipe or fittings while attempting to open the valves or cocks.

Summing up the principal causes of failures, one finds that a number of factors are more or less responsible for the accidents from this source, the most important ones appearing to be:

1. Allowing the blow-off pipe to be exposed to the products of combustion for too long periods of time;

2. Allowing pipe to become clogged;

3. The use of improper materials in pipes and fittings;

4. Improper installation of pipe;

5. Installation of valves or cocks unfit for the purpose;

6. Thoughtlessness or carelessness in operating.

* From *California Safety News*, March, 1926, Vol. 10, No. 1.

As a guide in the correction of these faults, the following requirements should be complied with:

1. Blow-off pipes and fittings should not be exposed to the products of combustion but should be shielded from such contact; whether exposed or not, such pipes and fittings should be renewed at regular intervals as conditions of service and pressure may require;

2. Blow-off should be operated often, to insure against clogging, or some circulating device installed that will keep mud and scale from settling in the pipe;

3. Only steel pipe and fittings should be used of a weight to meet the requirements of the 1924 Edition of the A. S. M. E. Boiler Construction Code;

4. The installation of the blow-off should be given as much thought and done with the same painstaking care as the installation of the main steam outlet piping;

5. Quick opening valves or cocks should not be installed in the blow-offs of boilers carrying high pressure. The 1924 Edition of the A. S. M. E. Boiler Construction Code calls for slow opening valves;

6. Books could be written on the subject "Human Equation." Ever since man has been and as long as man will be, the thoughtless and the careless have been and will be. But let us not become discouraged. We will be able to arouse the thoughtless and make the careless more careful.

The opening of a blow-off valve or cock should be done with deliberation—slowly and steadily—first to reduce the shock produced by bringing the water in the boiler in motion, and then to give warning in case someone be near the outlet.

The valves and cocks should always be kept in good working condition, so as to assure their operation with ease and safety. It is also very important that the end pipe outside of the valve or cocks be so secured as to prevent any great amount of movement when blow-off is opened.

If two or more boilers have their blow-off connected into a common line, the operator must make sure that blow-off valves on the rest of boilers are closed tight (whether boilers be empty or under pressure), before attempting to open any blow-off valve or cock.

Never use a hicky (club) on valves or long wrenches on plug cocks when opening, while the pressure is on.

The next time you find the valve or plug in cock stuck, and you are tempted to use a hicky or a long wrench, *stop, brother, don't do it!* Think of the possible consequences. Think of those depending on you. If *you* have no dependents, think of those near by who may have. Don't let your friends say, "Too bad. Jim was a fine fellow, but just a little bit careless."

[W. E. S.]

Sugar Prices

96° Centrifugals for the Period March 16, 1927, to June 14, 1927

Date		Per Pound	Per Ton	Remarks
March	16, 1927	4.74¢	$94.80	Cubas.
"	17	4.90	98.00	Cubas.
"	18	4.68	93.60	Porto Ricos.
"	21	4.695	93.90	Porto Ricos, 4.68; Cubas, 4.71.
"	22	4.68	93.60	Porto Ricos.
"	23	4.71	94.20	Porto Ricos.
"	24	4.68	93.60	Porto Ricos.
"	28	4.65	93.00	Cubas.
April	4	4.595	91.90	Porto Ricos, 4.61; Cubas, 4.58.
"	5	4.52	90.40	Philippines.
"	6	4.535	90.70	Porto Ricos, 4.55, 4.52.
"	7	4.6133	92.27	Cubas, 4.58, 4.65; Porto Ricos, 4.61.
"	8	4.63	92.60	Cubas, 4.61; Philippines, 4.65.
"	11	4.71	94.20	Cubas.
"	12	4.755	95.10	Cubas, 4.74; Porto Ricos, 4.77.
"	14	4.80	96.00	Cubas, 4.77, 4.83; Porto Ricos, 4.80.
"	18	4.83	96.60	Cubas.
"	19	4.77	95.40	Philippines.
"	20	4.865	97.30	Porto Ricos, 4.83; Philippines, 4.90.
"	21	4.90	98.00	Porto Ricos.
"	25	4.86	97.20	Porto Ricos.
"	27	4.83	96.60	Philippines.
"	28	4.77	95.40	Cubas.
May	2	4.74	94.80	Cubas.
"	5	4.77	95.40	Cubas.
"	7	4.815	96.30	Cubas, 4.80, 4.83.
"	10	4.83	96.60	Cubas.
"	11	4.865	97.30	Porto Ricos, 4.83, 4.86; Cubas, 4.87, 4.90.
"	12	4.90	98.00	Porto Ricos.
"	13	4.87	97.40	Cubas.
"	14	4.83	96.60	Porto Ricos.
"	19	4.80	96.00	Cubas.
"	20	4.815	96.30	Cubas, 4.80; Philippines, 4.83.
"	21	4.87	97.40	Cubas.
"	25	4.815	96.30	Philippines, 4.80, 4.83.
"	26	4.8533	97.07	Porto Ricos, 4.83, 4.86; Cubas, 4.87.
June	1	4.815	96.30	Cubas, 4.80; Porto Ricos, 4.83.
"	3	4.77	95.40	Cubas.
"	6	4.74	94.80	Cubas.
"	7	4.65	93.00	Cubas.
"	9	4.58	91.60	Porto Ricos, 4.61, 4.55.
"	14	4.52	90.40	Porto Ricos.